An Analysis of the Trauma Management System in a Predominantly Rural New Zealand Setting: A Preventable Death Study

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ABSTRACT

A one-year prospective study of all trauma deaths in the greater Manawatu region is reported on in this thesis. The aims of the study were to first, establish a database of the trauma deaths and second, to analyse trauma management systems within the region. A total of 56 cases satisfied the inclusion criteria for the 12-month study period. Deaths by category of trauma for the population were 31 (55.3%) road crash victims; 16 (28.5%) deaths due to suicide; five (8.9%) homicidal deaths; and, four deaths due to other causes, namely a fall, an electrocution, burns and one drowning following a head injury. Of these 36 (64%) were found by ambulance services to be 'in cardiac arrest' and five (8.9%) were 'not in cardiac arrest' but died later at the scene. One case died in transit and 14 cases (25%) died in hospital. Data on pre-incident factors such as alcohol, speed and safety practices showed that eight (24%) of the 31 motor vehicle related deaths had positive blood alcohol levels. Inappropriately high speed was an additional factor in three of these deaths as was the absence of safety equipment. Co-morbidity, where this existed, was also found to be a significant factor. Post-incident factors which influenced the fatal outcome of the incident included geographical location and ensuing access to the individual, the actual injuries sustained, and the provision of timely and appropriate treatment of injuries. An expert panel was convened to classify the deaths and evaluate the care provided by personnel in the trauma management system. The panel identified a number of pre-hospital and in-hospital deficiencies but determined that these deficiencies had no effect in terms of deaths. Of the twenty cases evaluated, eighteen deaths were classified as 'not preventable', one death was unable to be classified by the panel, and one death was classified 'possibly preventable'. If the trauma system in the greater Manawatu region had been flawless one life may have been saved – (5%) of the trauma death population. It is recommended that an efficacy study (encompassing both live and dead trauma victims) is conducted in the region to provide a more accurate perspective and evaluation of the trauma management system. The opportunity exists for further research to be conducted in an area with a similar geography and population distribution, also serviced by one second-level hospital, that does not currently have a regional trauma system in place.

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Confidentiality

Some cases included in the trauma death population may be identified through the inclusion of information provided in this thesis. This is not the intention of the author. It is requested that should identification of any victim occur, that confidentiality is respected.

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CHAPTER ONE: TRAUMA MANAGEMENT SYSTEMS IN THE GREATER MANAWATU REGION

1.1 Introduction

Trauma has been identified as one of the leading causes of death in New Zealand for persons under 40 years of age (Mathews, Metcalf, & Stewart, cited in Smeeton et al., 1987). The prevalence of deaths from trauma and the ability of medical intervention to prevent these deaths on a national basis have so far received minimal attention from researchers. Only one study on deaths resulting from trauma in New Zealand has been published to date (Smeeton, Judson, Synek, Sage, Koelmeyer, & Cairns, 1987).

Smeeton et al. (1987) acknowledge that definitive treatment of trauma patients in New Zealand has been expedited by the development of regional trauma services and the formation of trauma teams. Progress in trauma management has resulted in a dramatic reduction in the annual population of deaths due to trauma. Despite the improvements in pre-hospital, resuscitative, surgical and critical care, the estimated incidence of preventable mortality is still between 2 - 9% (e. g., Davis et al., 1992).

A review of the literature on trauma deaths has identified that within regions, the population of deaths due to traumatic injury represents a reliable (average) annual population volume (e.g., Maio, Burney, Gregor, & Baranski, 1996). Maio et al. suggest that if trauma care in their study region was flawless, and they had the ideal system, the expected reduction in trauma mortality could reasonably be expected to fall by only about 10% or less (p. 89). The authors recommend that by recording the population of trauma fatalities within a region, and through identification of the number of potentially preventable deaths, policy makers are able to redirect resources from those currently used to treat preventable fatalities to injury prevention.

A one year study of the management of trauma deaths in the greater Manawatu region (pop. 177,618) is reported on in this thesis. Motivation for the study, and the selection of the target region was determined by the author's work experience as a Registered Intensive Care Nurse in Palmerston North, the region's largest urban centre (pop. 72,000); the locality of Massey University's main campus and hence supervision; and, a request for an evaluation of the trauma management system in the Manawatu region by an Intensive Care specialist.

It was not known whether the population of deaths due to trauma in the Manawatu region could be reduced by improved trauma management systems. Data obtained from this study will be made available for use by the appropriate agencies to address avoidable trauma fatalities in the Manawatu region. One aim of the study is to make general recommendations for public education in the region, with regard to alcohol related incidents, the appropriate use of safety equipment and the abuse of speed.

1.2 Purpose of the Study

The aims of the research were:

1. To establish a database of trauma deaths in the greater Manawatu region (MidCentral Health primary catchment area) to facilitate the collection of data,

2. To analyse regional trauma management systems and elements of these trauma systems where appropriate,

3. To demonstrate the relationship between trauma deaths and such factors as the relevance of alcohol, the use of safety equipment and the abuse of speed in traumatic incidents.

An analysis of *all* data collected on every trauma death that occurred in the calendar year from July 1998 to June 1999 in the greater Manawatu region is reported on in this study.

The analysis of such a comprehensive data set enables current regional trauma management systems to be reviewed.

1.3 Significance of the Study

Data on deaths due to trauma in the Manawatu region is currently collected by a variety of bodies and organisations for a range of purposes. However, this information is not readily accessible. Agencies such as the Accident Rehabilitation and Compensation Insurance Corporation (ACC), the Land Transport Safety Authority (LTSA) and the Injury Prevention Research Unit (IPRU) collect information on isolated categories of traumatic death. For example, the LTSA collect and collate data on road deaths, while the IPRU collect data on deaths due to drowning and suicides. The police collect data on the total population of traumatic deaths but this information is not used to address the total population of trauma fatalities in terms of injury prevention.

Although there are numerous published studies focusing on the preventability of death after trauma, most international studies tend to focus on intra-hospital trauma care between tertiary level institutions in metropolitan areas. The single New Zealand study, now fifteen years old (Smeeton et al., 1987), of trauma management in the Auckland metropolitan region is of limited application to trauma management in the Manawatu: A region characterised by a large rural population; numerous small towns; and, one regional city. The Manawatu is, therefore, representative of much of New Zealand excluding Auckland and Wellington. While international studies pertaining to rural areas are limited in number, there are even less that encompass both urban and rural areas in one region. The present study contributes to the literature on preventable deaths by analysing trauma deaths in a mixed rural and urban region.

A second area of contribution from the study relates to the identification of deficiencies in the systematic collection of information on trauma death. These deficiencies were expected to include information obtained through autopsy, blood alcohol assays, the use of safety equipment and other factors such as speed in motor-vehicle related incidents. Although it is legally required that an autopsy is performed on all persons who die as a result of trauma (Coroner's Act, 1988), this appears to be at the discretion of the regional Coroner and some individuals are in fact not subjected to an autopsy. Therefore, the cause of death and precipitating factors to the death, often remain inconclusive. Similarly, blood alcohol assays may not routinely be conducted as a part of an autopsy. Information on blood alcohol levels is important in determining the percentage of traumatic deaths involving alcohol. Data on alcohol related deaths assists researchers in assessing the significance of alcohol as a precipitating factor in the population of trauma deaths.

Three other pre-incident factors that potentially contribute to reducing trauma deaths are seldom recorded. These factors include the use of safety equipment, safety practices, and the appropriateness of speed where a vehicle is involved. These factors were highlighted in the death of Diana, Princess of Wales, her companion Dodi al-Fayed, and the driver of their car in Paris on August 31st, 1997. The sole survivor was Diana's bodyguard, a front seat passenger and the only occupant wearing a seat-belt. Despite the excessive speed that the Mercedes Benz was being driven at, the bodyguard, although severely injured, survived the ordeal. The inquiry into the incident showed that in addition to the excessive speed and the fact that seat-belts were not worn by all three of the deceased, the driver's blood alcohol level was well over the legal limit for driving (Sancton & MacLeod, 1998). These pre-incident factors, often significant in trauma deaths, do not usually attract the attention that they deserve.

The emergency management of Diana, at the scene of the incident has also been scrutinised. Various trauma specialists and proponents of both the 'scoop-and-run' approach to trauma management versus the 'stay and stabilise' approach have debated both the time delay in transporting Diana to the hospital and the medical treatment she received at the scene of the incident (Sancton & MacLeod, 1998). The 'scoop and run' approach requires that the minimum amount of medical intervention is provided at the scene of the incident and the patient is transported to hospital as soon as possible. The 'stay and stabilise' approach recommends that relevant medical intervention is provided to the patient (in order to stabilise their condition) before transportation.

The approach to trauma management that is employed consistently throughout New Zealand is the 'scoop and run' approach. The exception is in the Hawkes Bay region where a doctor accompanies the helicopter on patient retrievals regardless of whether the patient is a trauma patient or a stable intra-hospital transfer. The 'scoop and run' approach is practised in New Zealand because ambulance officers retrieve patients. The level of qualification held by the ambulance officer then limits the treatment provided at the incident scene. This debate is discussed further in Chapter Two. The present study, by analysing each trauma death from all relevant perspectives, evaluated current approaches for trauma management at both the scene of the incident, during transportation and after arrival at hospital in order to make recommendations for the total trauma system.

1.4 Trauma Management Systems Within a Defined Region

The area serviced by Palmerston North Hospital and the St. John Ambulance Service's Central District within the MidCentral Health region includes both urban and rural areas serviced by one 'Level Two' Intensive Care Unit (see Glossary). In addition, the majority of deceased trauma victims in the study who arrived live at the hospital have been managed by Palmerston North Hospital staff and associated emergency services at some stage in the retrieval process. This situation provided an opportunity for analysis of post-incident trauma management systems within a defined region serviced by one major facility. There were exceptions; these occurred when individuals were transferred into Palmerston North Hospital from another region, (mainly for forensic post mortem examinations); or, were transferred out to either Wellington or Christchurch hospitals for specialist care at tertiary level facilities currently unavailable at Palmerston North Hospital. The later cases included patients with extensive burns (Wellington) and spinal injuries (Christchurch).

1.5 Thesis Outline

A review of relevant literature, incorporating both international and national studies, is presented in the following chapter. Chapter Three provides a description of the data collection techniques used and a brief introduction to the data set used for analysis. The results of the study are presented in Chapter Four, and the analysis and discussion of the population of trauma deaths in the greater Manawatu region is presented in Chapter Five. A critical discussion of the data collection process and analysis in trauma death studies is also included in Chapter Five. Recommendations for improvements to the trauma management system currently in place within MidCentral Health are then presented in the concluding chapter. Opportunities for further research of trauma management systems in similar regions are identified.

CHAPTER TWO: PREVENTABLE TRAUMA DEATHS – A REVIEW OF THE LITERATURE

2.1 Introduction

Literature on various international studies and the only other New Zealand trauma death study, have been reviewed. These studies incorporate relevant aspects of both the pre-hospital and in-hospital phases of care as well as rural and urban factors which impact on trauma death studies. The 'stay and stabilise' approach and the 'scoop and run' approach to trauma management are presented.

The chapter continues with a discussion of regional trauma systems and the importance of trauma registries. Findings from other studies on the relevance of pre-incident factors such as alcohol, inappropriate speed and safety practices and their relationship to trauma deaths follow. The chapter concludes with a synopsis of methodological issues and an alternative to the preventable death study.

2.2 Trauma Studies and Patient Management Systems

A proportion of deaths caused by trauma are preventable, an observation that has given rise to the concept of a 'preventable trauma death'. The preventable death is defined as a "death not related to the severity of injury but to a failure of treatment" (Stocchetti et al., 1994, p. 401). A commonly used indicator, the 'Preventable Death Rate', is used to consider the survival rate of the total population of severely injured persons and their potential for survival. The ratio of preventable deaths in a population of traumatic deaths is normally assessed by a medical audit based on clinical and post mortem data. A preventable death study can be used to detect failures in specific parts of a total trauma management system or overall systems failure.

Evaluation of trauma management should ideally involve an audit of the entire management system including the incidence of major complications. The application of appropriate management processes at specific points of the trauma management system should be included in the evaluation (Danne et al., 1998). Auditing of pre-hospital and in-hospital care of trauma patients, the management of urban versus rural trauma deaths, and the resultant preventable death data should be incorporated in the evaluation. Analysis of these parameters and identification of specific deficiencies in management enables a given system of trauma care to be altered following a clinical review process. Effective preventable outcome analyses have led to major changes in trauma systems and consequent reductions in potentially preventable deaths (Danne et al., 1998).

The criteria for auditing individual cases for classification of a preventable death vary with each study. Variations in preventable death study methodologies limit the comparisons of findings. Variances within methodologies include the panel composition for the evaluation of cases, the review process used, decision rules employed to determine the magnitude of agreement of the evaluative panel and the effect of the case-mix composition of the study population. There are numerous international publications on preventable death studies but only one New Zealand publication (Smeeton et al., 1987): These studies are now reviewed.

2.2.1 Studies of trauma death

Smeeton, Judson, Synek, Sage, Koelmeyer, and Cairns (1987) conducted a study of all deaths from trauma (236 deaths) in the Auckland region occurring in the year September, 1984 to August, 1985. The study area was serviced by the St John Ambulance Association and by the Auckland Hospital Board comprising four general hospitals: Auckland, Green Lane, Middlemore and North Shore. Data was collected on the circumstances of death from coroners' reports, post mortem reports, police and hospital records. The injuries sustained by the victims were scored using the Abbreviated Injury Scale (AIS) system 1980 and 1985 revisions. Blood alcohol assays were taken on all road traffic accident victims.

Of the study population in the survey by Smeeton et al. (1987), 236 deaths satisfied the initial study criteria. A total of 45 cases which met any one of the three criteria described below were then subjected to a retrospective medical audit undertaken by an intensive care specialist in conjunction with the post mortem report findings (p. 337). These criteria were: firstly, if the death occurred with a Maximum Abbreviated Injury Score (MAIS) score of four or less, indicating that a critical or unsurvivable injury was *not* sustained. Second, if the death occurred and the appropriate operation for the injury (craniotomy, thoracotomy or laparotomy) had *not* been performed; and third, if the appropriate operation for the injury was delayed.

Smeeton et al. (1987) recognised limitations in the method of audit used. In particular, there was no attempt to audit MAIS subjects that scored a five (critical) that had non-operable injuries. Therefore, aspects such as failure to recognise and treat shock may have been under-represented. For this reason Smeeton et al. (1987) suggest that any comparison of their results with other studies would be of limited value since uniform criteria for selection of assessment of preventability of death could not be guaranteed.

International preventable death studies reflect various themes. These themes include pre-hospital care, in-hospital care of trauma victims and urban versus rural studies. While some studies reported only on road deaths, others considered all trauma deaths in the study region. The majority of studies involved large populations of trauma victims serviced by a number of hospitals. The emphasis was on trauma management and clinical care, while information on contributing factors to the deaths, such as alcohol and safety devices (data collected for the present study) was minimal. Within the studies reviewed, the number of preventable deaths within the study population was considered. In some studies the audit involved all of the subjects in the study population, while in other studies the management of a subset of trauma victims who met a specific selection criteria was audited.

2.2.2 Pre-hospital care

Optimal treatment of severe trauma patients requires a chain of intervention before, during and after in-hospital management. Stocchetti et al. (1994) state that maximising survival requires quick diagnosis, resuscitation, and definitive therapy. The final result, they claim, will depend on the overall quality of the system, each phase playing a critical role in determining the outcome.

An unknown factor in most preventable death studies, is the length of time between the occurrence of the incident and the discovery of the victim. The initial trauma is often not witnessed and access to care is often delayed. Data from two studies (Esposito, Sanddal, Hansen, & Reynolds, 1995; Papadimitrio, Mathur, & Hill, 1994) identify cases where an individual survived the initial insult and the injuries sustained were treatable but the time between the incident and the initiation of treatment was found to be a significant factor in the death.

The basis of the *golden hour* principle for pre-hospital management of trauma patients is that definitive care, within one hour for the critically injured, is imperative for patient survival (Cowley cited in Royal Australasian College of Surgeons, 1994). Cowley's theory continues to be supported by most trauma specialists today.

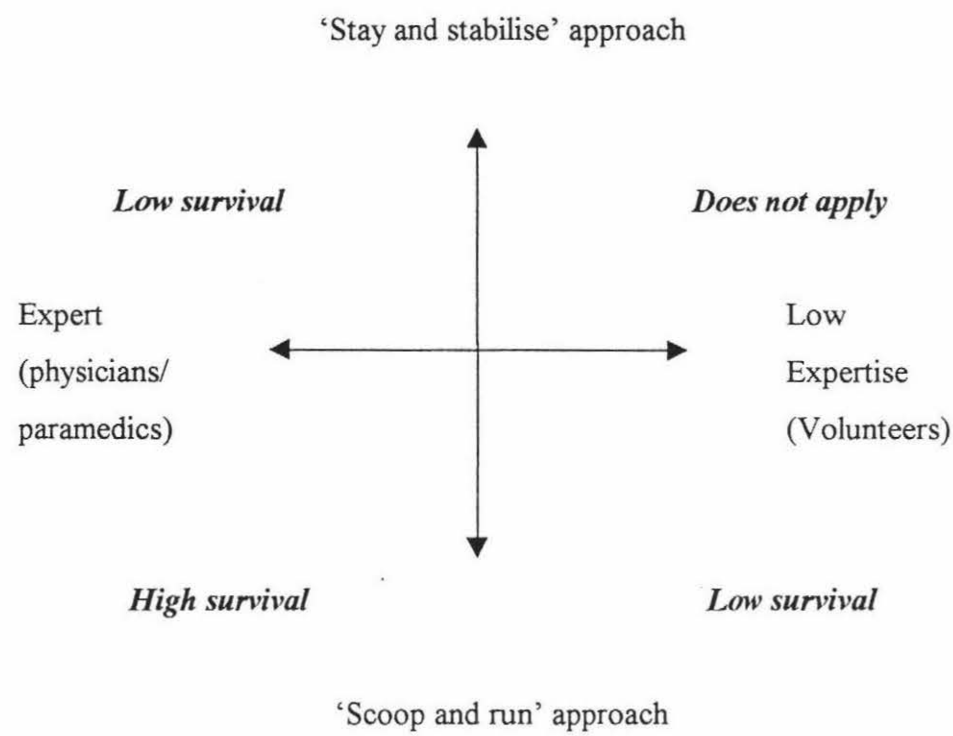
The debate of the 'scoop and run' approach versus the 'stay and stabilise' approach for the pre-hospital management of patients with severe injuries has had a resurgence since the road crash in Paris in 1997 which resulted in the death of Diana, Princess of Wales. Proponents of the 'stay and stabilise' approach believe that the establishment of intravenous lines with fluid replacement, intubation (where appropriate) and on occasion the application of anti-shock garments (MAST suits) should reduce the rate of physiological deterioration and assist in the stabilisation of the patient prior to arrival at hospital. The contrary argument is that those persons suffering from major trauma require definitive treatment within 60 minutes of the time of the incident and the administration of Advanced Trauma Life Support (ATLS) procedures performed at the scene of the incident will delay hospital arrival (Sampalis et al., 1995).

Sampalis et al. (1995) evaluated the effect of ATLS delivered by physicians to the victims of major trauma. The study showed significant pre-hospital delays and high rates of inappropriate intravenous initiation and intubation in trauma patients receiving on-site care by ATLS physicians. The authors commented that care provided by paramedics is standardised and conforms to a minimalist approach while on-site physicians are more inclined to provide unnecessary and time-consuming treatment. After evaluating the results of their study and the consequences of ATLS provided at the scene, the authors recommended the 'scoop and run' approach of pre-hospital trauma management. As noted in Chapter One, the 'scoop and run' approach to trauma management is practised by the majority of medical personnel in New Zealand. The 'stay and stabilise' approach, however, is mentioned in a number of international preventable death studies and reviewed later in this chapter.

There are three relevant issues in the pre-hospital management of trauma patients. These issues include: the provision of Basic Life Support (BLS); Advanced Trauma Life Support (ATLS); and, care provided by voluntary personnel. Most authors appear to agree that a delay in hospitalisation for the severely injured is detrimental to the final outcome and the pre-hospital management of the 'scoop and run' approach is preferred. Figure 2.1 presents the expected survival of victims as a function of the relationship between on-site trauma management and the competence of medical personnel. The 'highly qualified' (ATLS) personnel are on the left of the horizontal continuum with 'low expertise' (voluntary) personnel on the right. The vertical pole depicts the 'stay and stabilise' approach at the top and the 'scoop and run' approach at the base.

From the literature it is assumed that the trauma management of victims provided by personnel in the lower left quadrant (trained personnel employing the scoop and run approach) have the highest potential survival rate. Management of trauma victims within the upper right quadrant (volunteers/stay and stabilise approach) does not apply. Volunteers have a limited capacity for the provision of patient treatment. Therefore, if a volunteer is involved in patient care, the patient must be transported to hospital as soon as possible, this principal follows the 'scoop and run' approach. The remaining quadrants (qualified emergency service personnel, paramedics through to elementary care officers) provide a decreasing potential rate of survival as the level of qualification of the attending personnel diminishes.

Figure 2.1. Pre-hospital Management of Trauma Patients.



It is speculated that the preventable mortality rate from trauma in rural areas may be higher than that noted in urban areas because of extended distances and prolonged time to definitive care. This supports the "golden hour" theory and Trunkey's (1983) concept of a trimodal distribution of trauma deaths. Trunkey identified three peaks of when death post trauma is most likely to occur. The first peak 'immediate deaths,' occur soon after injury and encompasses 50% of individuals who sustain a major traumatic insult. The second peak, 'early deaths,' occur within the first few hours, and claim a further 30% of trauma victims. The third peak, the 'late deaths', occur days or weeks post-incident. The remaining 20% will have a chance of survival depending on the severity of injury, the type of injury incurred, the pre-hospital and in-hospital management received, and accessibility to the individual by medical personnel.

Esposito et al. (1995) suggest that time and distance factors may serve as a natural triage system in which those persons with non-survivable injuries often die before receiving medical attention. This, the authors say, may explain the lower death rate in rural studies in an area incorporating a remote environment, where the preventable death is one that is evaluated after the arrival of emergency service personnel. The authors Maio et al. (1996), state that even if the rural trauma system that is in place is flawless and the system ideal, the expected reduction in trauma mortality in most rural areas can reasonably be expected to fall by only 10% or less from the annual population of trauma deaths.

2.2.3 In-hospital care

Davis et al. (1991) found in their study that 50% of preventable deaths occurred during the in-hospital phase of care and were related to the size and designation of the centre. Critical care errors were categorised as errors in either management, monitoring, drug and electrolyte therapy or procedural/technical errors. One of the most common errors found by many authors in the in-hospital phase of care, is that of insufficient IV fluid resuscitation (e.g., Cales & Trunkey,1985; Maio et al., 1996).

2.2.4 Regional trauma systems

Two common features identified in the literature on preventable death studies are first, the importance of regional trauma systems and second, the recommendation for regional trauma registries [sic]. Many authors suggest that definitive treatment is expedited by the formation of trauma teams and the development of a regional trauma service (see Davis et al., 1991; Sampalis et al., 1995; Smeeton et al., 1987). Trauma teams are formed of surgeons and intensivists (or their understudies) who attend to victims on their arrival at hospital and rapidly diagnose and manage all injuries or refer patients to tertiary institutions where appropriate. In order to conserve resources and maintain expertise, it is recommended that only those hospitals with suitable facilities and qualified personnel receive victims of major trauma.

The maintenance of a regional trauma registry[1] and a system of outcome evaluation are recommended as essential components of any trauma care system (Champion et al.,

[1] Registry, as opposed to register, is the terminology observed for a database of trauma cases.

1990; Danne et al., 1998; McDermott, 1994; Smeeton et al., 1987). The development of trauma registries which facilitate the integration of information from both medical and system information into a single database, accompanied by standardised post mortem reporting of deaths, is recommended for accuracy (McDermott; Smeeton et al.). The extent of the injury problem, the treatment instituted, and its appropriateness in timing can be assessed objectively by evaluation of detailed information within set criteria (McDermott). McDermott also suggests that the scope of trauma registry data may involve all injuries or a subset of injuries and may be from a single source such as hospital medical records or multiple sources with the inclusion of police and ambulance records. Cales and Trunkey (1985) reported that the range of preventable deaths due to trauma in the United States was between 11% and 85%. Davis et al. (1991) report that following the development of regional trauma care systems, preventable mortality was reduced from 20 - 30% to 2 - 9%.

2.2.5 Pre-incident factors

Information on pre-incident factors contributing to trauma deaths, such as blood alcohol, speed, and the use of safety devices, was seldom included in the methodology of international studies. However, in the Auckland study, Smeeton et al. (1987) addressed the issue of blood alcohol levels but no other relevant pre-incident factors. Relevant information on pre-incident factors from the literature will now be discussed.

Papadopoulos et al. (1996) obtained the results of blood alcohol concentration measurements on 57 of the 82 persons who were Dead on Arrival (DOAs) in their study. The authors found that 10 (18 %) of the recorded cases had low or high concentration and the remaining 47 (82 %) had no blood alcohol at all. The authors state that alcohol is strongly associated with trauma death because even when the blood alcohol level was within the legal limits (less than 100 milligrams of alcohol per 100 millilitres of blood. NB. the New Zealand blood alcohol limit is currently 80 milligrams per 100 millilitres), injuries suffered by those in the alcohol-positive group were more severe than those in the alcohol-negative group. Papadopoulous et al. did not include screening for other drugs that may have synergistic effects with alcohol. However, the authors remark that in cases where there is a low concentration of blood alcohol in the traumatised patient other drugs should be considered to be likely causative factors of accidents.

Information on blood alcohol content was available in 76% of the cases audited (for preventability of death) in the study by Esposito et al. (1995). Alcohol was detected in the blood of 39% of all cases tested and 49% of motor vehicle related cases. Thirty-three percent of all fatalities studied and 43% of those who were drivers of motor vehicles or intoxicated pedestrians struck had a blood alcohol content greater or equal to 0.10, which was the legal definition for intoxication in Montana when the study was conducted.

Gorman et al. (1996) comment that one of the significant factors in preventable trauma deaths due to misdiagnosis was alcohol intoxication. Avoidable factors in 23 preventable head-injury deaths were presented as misdiagnosis of alcohol intoxication. Likewise, Papadimitriou et al. (1994) state that alcohol was an important factor in the deaths in their study in New South Wales (Australia) where 33% of those that were tested (16 of 49) had blood alcohol levels greater than 50 milligrams per 100 millilitres.

Blood alcohol levels were taken from subjects where the death occurred as a result of a road traffic accident in the Auckland study by Smeeton et al. (1987). The authors found that from mid-1984 to mid-1985 37% of the drivers and 50% of pedestrians who died had blood alcohol levels greater than 80 milligrams per 100 millilitres - the legal limit.

Rutledge & Messick (cited in Papadopoulos et al., 1996) suggest that alcohol is an important associative factor in all types of trauma-related mortality. The authors list alcohol associated-trauma deaths as: motor vehicle accidents, suicides, homicides, burns, gunshot wounds and, to a lesser extent but still significant, occupational deaths.

Of the literature reviewed, two studies included data regarding safety devices. Information on the use of restraining devices was available for 124 of 162 cases (76%) involving motor vehicle occupants; 17% were restrained and 83% unrestrained in the study by Esposito et al. (1995). The authors found that 56% of motor vehicle incidents involved single vehicle rollover crashes, 46% of the decedents in these cases were reportedly ejected from the vehicle. McDermott et al. (1997) found that 58% of the vehicle occupants that died were known to be wearing seat-belts at the time of the incident. There was evidence of a lack of safety restraints being used by 14% of the occupants who died, while six out of seven of the motorcyclists and cyclists that died were wearing helmets.

2.3 Methodological Issues

Methodologies used in preventable death studies are extremely variable. A comparison of results is, therefore, complicated. The evaluation of trauma death populations involves a number of issues, these include: The case-mix composition being evaluated; the composition of the panel used to evaluate cases; the decision rules employed to determine panel classification of the death; and, the review process employed. The review process may involve an independent review of cases, a group review, or a combination of both.

The information made available for review of the cases also has an impact on the validity of information: The inclusion of autopsy findings is a hotly debated issue. The classifications of death preventability and the problem categories used to assess the trauma system are also highly variable and poorly identified in many studies.

The remainder of Chapter Two presents a discussion on the issues mentioned above from a review of the literature. Other topics included in this chapter include the various methods employed to calculate trauma injuries and which of these methods was most applicable to the present study. The chapter concludes with a brief outline of an alternative to the preventable death study, the 'efficacy rate' method of assessment.

2.3.1 Evaluative panels

The preventable death rate is frequently used as a measure of the quality of trauma care. However, the results of most studies are unable to be compared by members of evaluative panels (McDermott et al., 1997). Wilson, McElligott and Fielding (1992) evaluated 34 studies on preventable death rates as a means of evaluating trauma care. The authors state that a specific description of the processes used to make case-specific judgements was found in only half of the studies reviewed. In addition, the minimum independent panel member agreement required to declare a death 'preventable' was explicitly stated in only five of the 34 studies.

Numerous difficulties are encountered when attempting to compare results from individual studies. These difficulties include the methods used in the evaluation process, which encompasses the composition of the review panel; the decision rules employed for determining the magnitude of agreement of the panel; the review process used; the information available for review and the variety of study populations that are evaluated. In addition, the definitions of death classifications used in studies are variable, while the definitions of problem categories used to evaluate the organisation's trauma system are non-standard. Each of these factors will now be discussed in detail.

2.3.2 Composition of panels

The peer group review panel (expert panel) is commonly used to identify errors or deficiencies in patient management contributing to mortality or morbidity. Panels may vary in composition, number and expertise. The evaluation of the death often begins with the individual panel member independently assessing each case. The evaluation is routinely followed by discussion among members as to the classification of the death (intra-panel agreement). It appears that this sequence is near universally adopted. In addition, agreement on classification by specialty, for example, neurological cases, may also be determined (intra-speciality agreement).

Maio, Burney, Gregor & Baranski (1996) employed two multi-disciplinary panels while MacKenzie et al. (1992) employed three panels in their studies. In each study the panel assessed all cases in order to determine the statistical agreement between members on the classification of death. In Smeeton et al's. (1987) study it appears that only one intensivist classified (as preventable or otherwise) 45 of the cases that were audited. A minimalist approach when compared with other trauma death studies.

The composition of an expert panel appears to vary according to the preference of those conducting the study. For example, a panel may be comprised of one or a number of trauma surgeons, general surgeons, intensivists, emergency physicians, neurosurgeons, orthopaedic surgeons, paediatricians, paramedics, nurses experienced in trauma and possibly a pathologist. The regular panel will audit cases and in addition a specialist may be called on to evaluate specific cases within their field of expertise, namely, a surgical paediatrician.

2.3.3 Panel review method

A variety of styles may be employed for the review of case-related information. Wilson, McElligott, and Fielding (1992) compared three consensus systems using separate five-member expert panels. Each of the panels assessed 20 non-central nervous system (non-CNS) fatalities. Three methods of evaluation were employed. First, independent judgement second, discussion preceding individual judgement and third, independent judgement followed by discussion. The study showed that the different review methods yielded different results; only one case in 20 was classified as preventable by all three review panel methods. In addition, the preventable death rate varied from 10 - 45%. The authors concluded that individual case review may be severely flawed and, therefore, should not be used to measure institutional quality of patient care.

Kelly & Epstein (1997) questioned the reliability and validity of preventable death studies using an expert panel method due to the panel members' subjectivity and the potential for bias. Although subjective, the panel method facilitates evaluation of the process of care, its appropriateness and its compliance with generally accepted principles of trauma care. Esposito et al. (1995) state that few reviewers and panels seem to disagree about the adequacy and appropriateness of care. The difficulties, they say, revolve around the degree to which inappropriate care has contributed to the death.

2.3.4 Classification of deaths

Authors of preventable death studies classify deaths using either a three or four point scale. The categories are generally either non-preventable; potentially preventable; probably/possibly preventable; and, definitely preventable. A non-preventable death (described by MacKenzie et al., 1992) is one where, in retrospect, with full knowledge of the clinical history and all injuries sustained, the injuries were generally non-survivable. The classifications of death are reflective of patient management after the injury and assume that management had conformed as closely as practicable to the generally perceived ideal. The *ideal* situation and treatment includes timeliness of treatment, transportation to the most appropriate hospital with the most appropriate facilities, and optimal patient management. A preventable death is one where, in retrospect and with full knowledge, the death would generally not have occurred (MacKenzie et al., 1992).

2.3.5 Decision rules for magnitude of agreement

MacKenzie et al. (1992) identified three rules to be used when determining the magnitude of agreement between panel members. The agreement rules are; the modified majority rule; the unanimous decision rule; and, the panel consensus rule. The modified majority rule states that there is initially an independent review of the deaths with final judgement taken as the majority opinion. If the majority opinion option is not available the case is discussed and a consensus of opinion developed. With the unanimous decision rule all reviewers need to be in agreement about the preventability of the death. Finally, with the panel consensus rule the classification of preventability reflects the consensus of the panel or the majority opinion if no consensus is reached.

MacKenzie et al. (1992) stated that the unanimous decision rule is clearly the most conservative method for determining preventable deaths. In general, the number of deaths judged preventable using the unanimous decision rule was less than half of the number of deaths judged preventable using either the modified majority rule or the panel consensus rule. However, none of the approaches appeared to stand out as substantially more reliable, as evidenced by the large discrepancies across panels. The authors suggest that the unanimous decision rule provides an estimate of the lower bound of the true preventable death rate and the panel consensus approach (using a multidisciplinary panel), an estimate of the upper bound (p. 296). McDermott et al. (1997) found that unanimous judgements were most frequent with non-preventable deaths and least frequent with preventable deaths.

2.3.6 Review process

Many authors (McDermott et al., 1997; MacKenzie et al., 1992; Wilson et al., 1992) state that judgements made on the preventability of trauma deaths were found to differ between pre-meeting assessments and those made after multidisciplinary discussion. Multidisciplinary discussion has been shown to modify the judgements of committee members in previous studies and result in higher agreement. A dominant panel member has been found to influence the opinion of other panel members and, therefore, affect the reliability of classification of a death, particularly if the panel consensus method is employed.

The use of panel discussions following independent reviews, as opposed to using a majority or modified rule based on independent review, only provides a marginal increase in reliability. The increase in reliability was found to be more significant for CNS deaths and was age related. The lower reliability of preventable death judgements for older patients is likely to reflect general disagreement among physicians regarding the relative benefits of aggressive trauma care for the elderly (MacKenzie et al., 1992).

Genuine differences of opinion on trauma management, the time dynamic of trauma and the possibility of incomplete documentation will all have an effect on the review process. Inaccurate recordings of events will cause those evaluating the death to question the validity of preventable death judgements. Errors may be assigned to the different phases of care, for example, pre-hospital, emergency department, theatre and the intensive care unit. However, these separations are not always applicable because the treating personnel usually span more than one phase of care (Kelly & Epstein, 1997). The added stress of an emergency situation dictates that action rather than documentation is the priority. Therefore, the panel evaluating traumatic deaths must be cautious when making judgements based on inadequate information.

2.4 Autopsies

Many authors (McDermott, 1994; Smeeton et al., 1987; Stothert, Gbaanador, & Herndon, 1990) recommend a detailed post mortem examination (autopsy) on all fatalities for complete anatomical diagnosis of injury for quality care assessment in relation to trauma management. An audit undertaken between 1984 and 1988 examined the differences between clinical diagnoses and autopsy findings in 212 patients after receiving blunt injury, penetrating injury or thermal burns (Stothert et al., 1990). The autopsy rate for this study was 99%. Major discrepancies between clinical diagnosis and anatomic diagnosis at autopsy was identified in approximately 30% of the patients, and diagnostic error occurred in a further 5%. The authors state that these discrepancies may account for patient survival. The data supports the practice of obtaining complete autopsies on all patients that die as a result of trauma and the standardisation of performance and recording of autopsy reports.

Streat and Civil (1990) conducted a similar study to that by Stothert et al., (1990) on 'Injury Scaling at autopsy: The comparison with pre-mortem clinical data'. The authors found that although in non-surviving patients the autopsy examination provided anatomic data on all body regions, operative intervention or the process of recovery had in some cases abolished the evidence of injury. In addition, the authors commented that the autopsy examination appeared at times to be too crude to reveal subtle cellular damage with significant physiologic consequences.

Streat and Civil (1990) give examples of the frequency and extent of rib fractures, pulmonary contusions and haemomediastinum, which was found to be greater at autopsy than had been appreciated clinically. Another aspect identified in their study was the failure to diagnose a flail chest, a pneumothorax and a haemothorax at the autopsy examination either because of the time from the occurrence of the incident; the treatment administered and the subsequent resolution of the injury; or in the case of a flail chest, the requirement for this to be observed on a respiring patient. Oesophageal perforations, lacerations to the lung, the pericardium and the aorta were also found at the autopsy examination but not appreciated clinically. Streat and Civil, therefore, recommend that the autopsy process is both standardised and guided by a thorough clinical examination as well as progress notes from the time of hospital admission (pre-motem clinical data) until the time of death. Additionally, any complications in the recovery process should be documented and accounted for.

In addition to standardised autopsy reports, some authors (MacKenzie et al., 1992; McDermott et al., 1997; Maio et al., 1996) advocate the review of complete medical records, pre-hospital records, autopsy reports and coroners' reports on trauma subjects. MacKenzie et al. found that the percentage of perfect agreement among the three panels used in their study increased from 38 - 53% when autopsy reports were available and from 30 - 50% when pre-hospital records were available. In comparison Wilson, McElligott and Fielding (1992) withheld autopsy data from the review panel members in their study. Wilson et al. (1992) argued that the purpose of their study was to evaluate the decision reached by the panel (on classification of the death as preventable or otherwise) based on information available at the time of clinical management. Autopsy reporting within the literature reviewed for the present study ranged from 100% (Smeeton et al., 1987) to 20% (Maio et al., 1996).

New Zealand legislation requires an autopsy to be performed on all deaths due to trauma (Coroner's Act, 1988). Despite this legal requirement it is not uncommon for trauma victims to be exempt from an autopsy. The omission of an autopsy is determined by the Coroner who, because of the circumstances and the injuries incurred, may determine that there are no grounds for suspicion associated with the death and, therefore, no requirement for an autopsy.

2.5 Calculation of Injuries

A uniform approach to the grading of the severity of injuries is recommended when undertaking a preventable death study (McDermott, 1994; Civil, 1997). Both authors suggest the use of scoring systems such as the Revised Trauma Score (RTS), the Injury Severity Score (ISS) or the more recently developed TRISS methodology which combines the Trauma Score, the Injury Severity Score and age.

The Injury Severity Score (ISS) developed by Baker, O'Neill, and Haddon (cited in Association for the Advancement of Automotive Medicine, 1990) is an index of anatomic injury severity used for describing patients with multiple injuries and evaluating emergency care. The ISS is the sum of the squares of the highest score on the Abbreviated Injury Scale (AIS) in each of the three most severely injured ISS body regions (Association for the Advancement of Automotive Medicine, 1990). The body is divided into nine regions for the purpose of AIS coding. However, in order to calculate the ISS, six different body regions are used (see Appendix One).

The AIS is a list of several hundred injuries. The Abbreviated Injury Scale scoring system divides the body into nine separate body regions. These are the head; face; neck; thorax; abdomen; spine; upper extremity; lower extremity and external (including burns and other trauma). In the AIS, each injury description is assigned a unique six-digit numerical code in addition to the AIS severity score. The severity score (the digit to the right of the decimal point) is the AIS which ranges from one (minor injuries) to six (injuries that are nearly always fatal).

One limitation of the ISS is that only three of the most severely injured body regions are considered, therefore, a given ISS value may include a variety of AIS injury combinations associated with different mortality risks (Champion et al., 1990). A second limitation of the ISS, is that it is difficult to calculate the scores derived from the nine body regions of the AIS into the six ISS regions.

Smeeton et al. (1987) used the AIS system and the Maximum AIS (MAIS) grading systems. The MAIS is defined as the highest single AIS code and represents the severest injury incurred. The range is on a scale of one to six. A grade one injury is considered to be minor; two, moderate; three, serious; four, severe; five, critical; and, six, unsurvivable. The MAIS was found to be deficient due to its nonlinear relationship with the probability of death and was, therefore, succeeded by the AIS. The MAIS system of scoring used in the study by Smeeton et al. was not used by other authors in the studies reviewed.

Boyd, Tolson, and Copes (1987) are advocates of preventable death study evaluation using the TRISS (Trauma Score, Injury Severity Score and age) methodology.

These authors state that TRISS is useful for comparing national standards; for quality assurance review on a local basis; as well as a means of comparing outcomes for different populations of trauma patients (p. 370). Papadimitriou, Mathur, and Hill (1994) also identify the TRISS analysis as a reliable audit filter for the pre-hospital treatment of trauma deaths, however, they state that the TRISS analysis is only useful in estimating the probability of survival of patients after the arrival of pre-hospital personnel at the scene. TRISS does not help identify those deaths that were potentially preventable if access to care had been faster, such as those persons who were dead when the emergency services arrived and those, who still initially alive on arrival of emergency service personnel, had no hope of survival. Wilson, et al. (1992) also comment on the limitation of the TRISS methodology for determining survival probability because of the division of age into [only] two groups and the failure of the programme to allow for pre-existing disease.

In 1997 Osler, Baker, and Long developed a modified version of the Injury Severity Scoring (ISS) system called the New Injury Severity Score (NISS). The authors recognised both the contribution that the ISS had as a means of measuring anatomic injury and the limitations of the system. The ISS, the authors state, has an idiosyncrasy that both diminishes its predictive power and complicates its calculation. This deficiency occurs because the ISS considers only one injury per body region and, therefore, may omit significant injuries from the scoring process if the patient sustains multiple injuries to a single body region. In this case, only the single worst injury contributes to the ISS.

Secondly, in patients with injuries in several regions, the ISS is constrained to consider a second, perhaps less severe injury in a second body region and often fails to consider more severe injuries in favour of less severe injuries that happen to occur in other body regions. A third and fundamental deficiency of the ISS, is the complexity of the scoring system. Not only must every injury be assigned to a body region before scoring, but the six body regions used in the ISS do not correspond to the nine anatomic body regions of the AIS lexicon. Osler, Baker and Long (1997) state that this complexity increases the likelihood of scoring errors and hinders the mental estimation of the ISS. The authors state further, that the original intent of the ISS to consider the body as a whole is, therefore, in conflict with the more fundamental principle that more severe injuries should be considered over less severe injuries. Consequently limitations of the ISS must include the loss of predictive power.

The NISS developed by Osler, Baker, and Long (1997) considers the sum of the squares of the AIS of a patient's three most severe injuries, regardless of body region. The authors state that its predictive accuracy can be increased by the addition of other types of information to the scoring process, this includes the patient's age, physiologic derangement (usually specified within the Revised Trauma Score-RTS) and a combination of the anatomic and physiologic data for outcome prediction using the scoring system ASCOT (American College of Trauma Surgeon's Committee on Trauma). Because NISS was found to predict more accurately the survivors from the non-survivors of traumatic injury the authors advocate its adoption in favour of the ISS system.

2.6 Case-mix Composition

MacKenzie et al (1992) examined the potential reproduction of preventable death judgements between three three-member panels that reviewed 64 non-Central Nervous System (CNS) deaths and between three different panels who examined 62 CNS deaths. Agreement was higher for early deaths (within one day) and less severely injured patients. The authors reported poor agreement for non-CNS deaths and only fair agreement for CNS deaths. MacKenzie et al. state that in general reliability of preventable death judgements for trauma is low. They qualify this statement with statistics that three of their panels reviewing non-CNS deaths agreed in only 36% of cases, while agreement among panels for CNS deaths was 56%. The authors suggest that evaluation of patients with head injuries is less complicated. This is possibly because the likely outcome, according to the severity of the head injury, is able to be predicted by a neurosurgeon with more certainty than the outcome of patients who have incurred injuries to multiple body regions requiring input from a number of specialists. For this reason these authors encourage those cases classified as early deaths, the less severely injured, and non-CNS cases to be evaluated within their own categories.

Limb et al. (1996) and Esposito et al. (1995) recommend that researchers of preventable death studies identify the proportion of patients diagnosed as 'dead at the scene' of the incident and those showing vital signs at the scene, but who were 'dead on arrival' at the emergency care facility. Their reasoning is that those who were dead at the scene consist of a much more severely injured population with a lower potential salvage rate.

2.7 Definition of Problem Categories

Much of the literature identifies and condemns individual services or departments involved in trauma care, such as pre-hospital, emergency department, operating theatre and intensive care. Trauma management within these areas may be found to be deficient and blame apportioned accordingly. However, some authors suggest that this division is arbitrary because a specialist (such as the intensivist) often escorts the patient through the entire hospital system (Kelly & Epstein, 1997).

Many authors encourage the introduction of a standardised methodology and format for evaluation. McDermott et al. (1997) recommend categorisation of problems for panel assessment to include headings such as system inadequacy; errors in treatment, therapeutic or diagnostic decision made contrary to management strategy (i.e. recommended optimal standards of practice); error in technique; error in diagnosis; and delay in diagnosis.

2.8 An Alternative Methodology for Preventable Death Studies

Due to the variances within preventable death study methodologies, the authors Salmi et al. (cited in Danne, 1998) recommend an '*efficacy rate*' method of assessment as a tool to evaluate all processes of trauma care audit. The efficacy rate is an assessment of the survival rate among those patients with a potential to survive and includes all survivors and all deaths following a traumatic incident. The preventable death rate in comparison provides no information on the group of patients who had the potential to survive as it focuses only on the fatalities and, therefore, little information is available on the quality of care provided. The existence of a trauma registry will facilitate the efficacy rate method of auditing trauma care.

2.9 Summary

The main issues to emerge from the literature are the 'scoop and run' versus the 'stay and stabilise' approaches to pre-hospital trauma management relative to the consequences of care received by the trauma victim. Although emergency medical care in New Zealand follows the 'scoop and run' approach to trauma management, there are international proponents who advocate the 'stay and stabilise' approach. The qualification and competence of pre-hospital personnel attending the trauma site is an important factor in the chain of patient survival. Information on the qualification of emergency service personnel attending the incident needs to be collected to evaluate this aspect of the trauma management system.

The importance of regional trauma systems and trauma registries was discussed in view of auditing trauma management systems. However, completeness of data and standardised evaluation criteria are imperative if results are to be compared.

A methodology modelled on that used by Smeeton et al. (1987), the only previous New Zealand study, is employed in the present study in order to assist comparability. Variants within the present study from that used by Smeeton et al. will include a multi-disciplinary panel in place of a one-member auditor, and the injury classification used by most other authors - the Injury Severity Scoring (ISS) system. In addition, the New Injury Severity Scoring system (NISS) has been used. Autopsy findings will be an essential part of the evaluation process.

An urban/rural dimension in the present study is indicative of the patient population presenting to regional trauma systems throughout much of New Zealand. The present study goes further than those studies reviewed by including relevant factors to trauma deaths such as pre-incident morbidity, use of alcohol, abuse of speed and safety practices.

CHAPTER THREE: RESEARCH METHOD

3.1 Chapter Outline and Identification of Data

The design of the study is described and the specific objectives are identified in this chapter. The trauma management system and relevant documentation used are presented in the form of flow charts. Palmerston North Hospital's policies on the management of trauma patients and the collection of blood alcohol assays are described. The chapter concludes with a summary of the process used to evaluate patient management through the trauma system and the subsequent classification of death preventability. This assessment was done by a multi-disciplinary panel of trauma specialists.

The broad aims of the study were first, to establish a database of trauma deaths in the greater Manawatu region and second, to analyse trauma management systems and elements of these trauma systems where appropriate. Third, in view of the first two aims, it was expected that the data generated could be used to educate the public on the abuse of alcohol, safety practices, and the abuse of speed in fatal traumas.

The specific objectives of the study were:

1. To determine the *incidence of death from trauma* in the greater Manawatu region during a twelve-month period.

2. To determine *pre-incident factors* that may have a bearing on the occurrence of the incident and the nature and severity of the injuries.

3. To determine factors in the trauma management system and other *post-incident factors* that may have influenced the fatal outcome of the incident.

4. To describe the relationships between the *mortality of the victim*, and other factors such as age and prior morbidity.

5. To *review current trauma systems and trauma management* in the Manawatu region in order to identify any deficiencies and make recommendations to improve trauma management systems.

6. To identify the *preventable trauma deaths* within the study population.

Both quantitative and qualitative methodologies were employed. The study sought to establish quantitatively the number of persons who died as a result of trauma in one calendar year, the nature and severity of their injuries, and the type of trauma resulting in the death. Information about conceptual factors surrounding the traumatic incident was also collected. These factors included the presence and volume of alcohol per litre of blood, the use of safety equipment, safety practices, and, the relevance of speed to the fatal outcome.

The principal sources of data were documents completed on the individual by the range of personnel progressively involved in dealing with the trauma (as described later in this chapter). The study was characterised by a technique involving the analysis of archival information. Employment of this technique enables questions such as who, what, where, how many, and how much (Yin, 1989, 1994) to be asked. Archival research does not require control over behavioural events making this the strategy of choice in tackling the emotive and sensitive issue of death by trauma.

The data was supplemented, sometimes clarified, and expanded qualitatively through informal contacts with relevant personnel. This was done by telephone with police and discussion with ambulance officers who had had contact with the deceased post-incident. Further qualitative analysis was used in the study with the panel of medical experts who classified the deaths in terms of preventability. Although archival information routinely documented was the principal source of data, the study was conducted in a prospective manner. St. John Ambulance personnel and other personnel involved in trauma management were informed that the study was in progress. Although this introduced the potential for bias, in terms of management of trauma victims and documentation of treatment when compared with patient management and documentation under normal conditions, it was felt that this could only be a positive effect of the study.

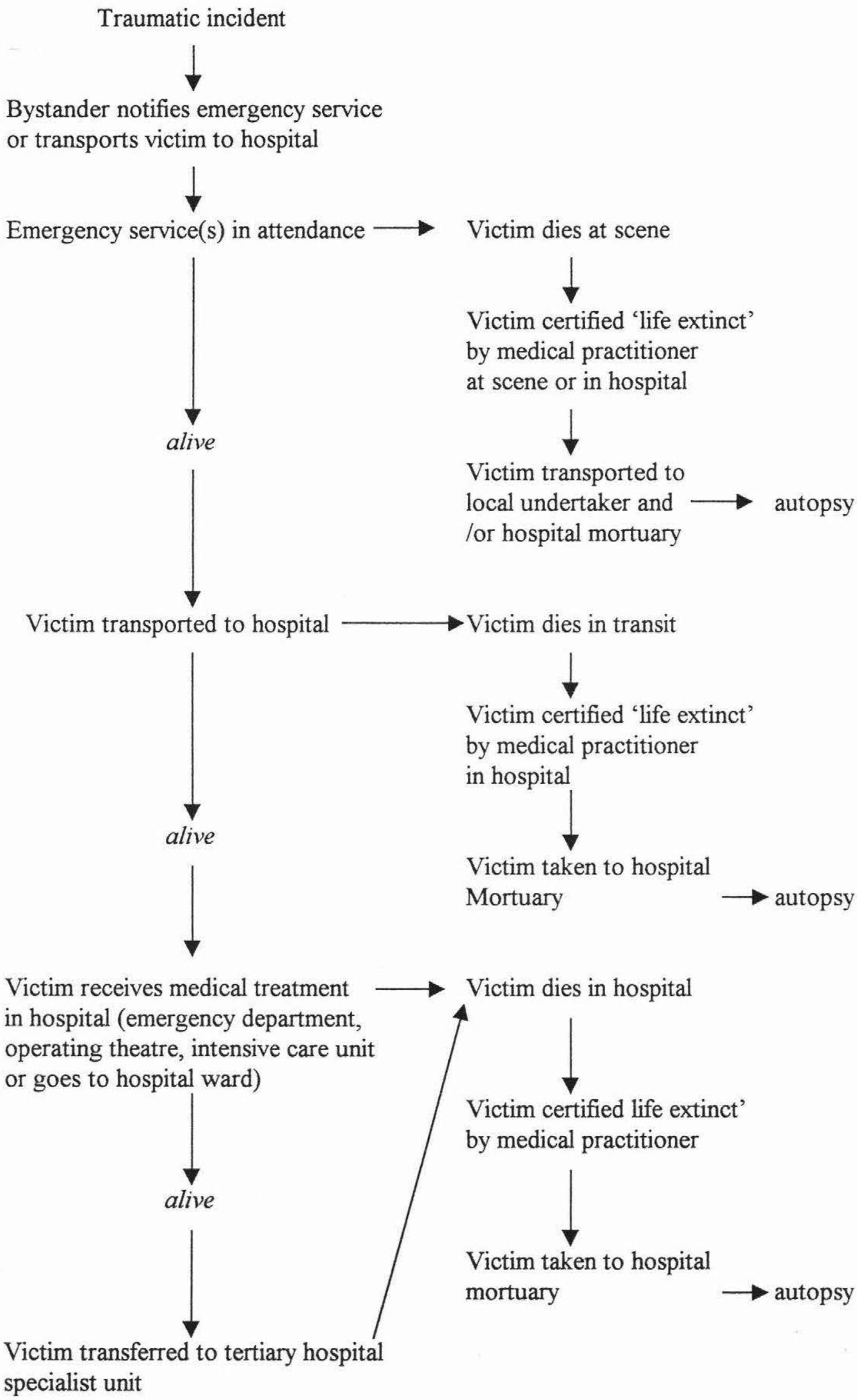
As noted in Chapter Two, the present study employed a modified methodology, based on the twelve-month prospective study undertaken by Smeeton, Judson, Synek, Sage and Koelmeyer (1987) on *Deaths From Trauma in Auckland: A One Year Study* from September 1984 to August 1985.

The population of the present study consisted of all persons who died as a result of trauma (defined as physical injury or thermal burns) in the MidCentral Health region over the twelve-month period from July 1st, 1998 to June 30th, 1999. Those who sustained a traumatic event within the region and were transported to another hospital and subsequently died outside the region, were also included. In these cases the initial management of the person was analysed. Elderly persons presenting with a fractured neck of femur were excluded from the study. The population of elderly persons presenting with a fractured neck of femur often have additional underlying medical conditions and is not considered to be representative of the population of trauma victims. This exclusion is common place in preventable death studies.

3.2 Trauma Management Systems

The sequence of events following a traumatic incident is shown in Figure 3.1. A bystander or witness to the incident will occasionally transport the victim to hospital by private transport or, more commonly, notifies one of the emergency services of the incident. If the bystander lodges a 111 telephone call to the Telecom operator following an emergency, and the caller does not specify the service, the operator is trained to question the caller about the incident in order to ascertain which service is required. The priority of emergency calls that Telecom operators observe follow the order of Fire, Ambulance, and lastly Police.

Figure 3.1. Trauma management flow chart.



All 111 requests for the ambulance service are transferred to regional headquarters while 111 telephone calls for the police are transferred to the Wellington Central Police Headquarters.

3.2.1 Palmerston North Hospital policy on trauma patients

Patients arriving at Palmerston North Hospital following a traumatic injury categorised as either a status code 1 or 2 patient (refer to Table 3.1 included) are treated by personnel comprising the 'Trauma Team' (Hicks & McKenzie, 1999). Categorisation of patient status is undertaken by either the ambulance officer prior to the patient's arrival, or by the emergency department house officer (Doctor) on arrival at hospital.

Table 3.1. Patient condition status codes and triage tags used for classification in Palmerston North Hospital.

	Status zero	**Status one**	**Status two**	**Status three**	**Status four**
Patient condition	Deceased	Critical/ Extreme	Serious	Moderate	Minor
Stability	Dead on arrival (D.O.A)	Unstable	Unstable	Stable	Stable
Potential to deteriorate	None	Obvious	Probable	Unlikely	None
Special criteria	Nil resuscitation attempt	CPR in progress and/or GCS < 9; Airway obstruction; Uncontrolled haemorrhage; Assisted respiration; Systolic blood pressure < 90 and pulse > 130 or < 50	CPR not in progress GCS > 9		
Triage tags		Priority 1	Priority 1	Priority 2	Priority 3

Source: Palmerston North Hospital Emergency Department.

The trauma team consists of the intensive care unit registrar; the general surgical registrar; the anaesthetic registrar; the emergency department nurse assigned to the area and the after hours nursing co-ordinator. A radiographer and transfusion medicine laboratory technician also attends the 'trauma call'. The trauma protocol states that the trauma team members must attend to any trauma call as a first priority. Each person on the team has designated responsibilities in the event of a trauma.

3.2.2 Palmerston North Hospital policy on blood alcohol assays

The Palmerston North Hospital policy on the management of trauma victims requires that during a trauma call it is the specific responsibility of the emergency department house officer to ensure that a blood specimen is sent to the hospital laboratory for a blood alcohol assay (Hicks & McKenzie, 1999). A hospital blood alcohol level is required for treatment purposes. In addition, the police may require any person who is responsible for the lives of others, while either operating a vehicle or machinery, to have a blood sample taken and sent to the Environmental Science and Research Institute (ESR) for a blood alcohol level following a traumatic incident. If the driver of the car or motorcycle is unknown, then a blood sample is taken from all persons. The blood sample is sent to the ESR for a formal blood assay, the result of which may be used as evidence.

If the trauma victim dies in hospital before the ESR sample is taken and/or after receiving extensive treatment with resuscitating fluids, an ESR blood alcohol sample may be omitted. The decision to take the ESR blood alcohol sample after death is at the discretion of the pathologist. However, because the volume of resuscitating fluids given to these patients will alter the assay results, a blood alcohol sample is often omitted.

3.3 Emergency Services

After receiving the telephone call notifying the emergency service of a traumatic incident, the emergency service will dispatch a vehicle to the scene. Both the ambulance and the fire service follow a protocol regarding notification of the other services. The procedure for the ambulance service is currently under review. However, the Regional Communications Centre (RCC) draft procedure for the Central Region (1995), which includes the greater Manawatu region requires that in addition to responding to the incident, the ambulance service notify the police of the following; road traffic crashes; fatal incidents from any cause; reports of criminal activity (assault, rape, gunshot wounds); air crashes; civil disturbances, search and rescue incidents; and marine emergencies. The fire service are routinely notified by the ambulance service of incidents involving fires; chemical/fuel or other dangerous goods; persons trapped and incidents in rural areas where the condition of the patient is considered serious and requires oxygen while awaiting arrival of the ambulance (Shewan, 1995).

The police are required to attend all traumatic incidents, particularly fatalities. However, the police do not have a formal protocol for notification of the other emergency services. The decision to call either the ambulance or fire service is left to the discretion of the officer on duty for each isolated incident. The information given to the police by the bystander influences their decision to call other emergency services. (Senior Constable P. Coss, personal communication, January 19, 1999). The fire service policy on notification of both the ambulance service and the police requires that the fire service operator notifies both emergency services for 'non-fire life threatening' calls, for example, suicide, extrication from machinery and any incident likely to involve a person or persons. (M. Cooper, fireman, personal communication, March 30, 1999).

3.3.1 Ambulance officer qualifications

The name and designated number of ambulance officers (and assisting personnel) who attend to any patient is recorded on the Ambulance Patient Report. There are four main categories of personnel who 'crew' the ambulances. The first group is classed as 'elementary'. The elementary officer will crew with the attending officer and may be either in the process of completing or preparing to sit basic qualification examinations. The exception to this rule is where the regional ambulance station is crewed by volunteers and personnel with only elementary qualifications. In such cases the elementary qualified ambulance officer may attend to an incident alone.

The second group is 'proficiency'. Proficiency officers have attained the National Certificate of Ambulance Care by the New Zealand Ambulance Board. The third group are 'Intermediate Care Officers' (ICOs) who are qualified with a National Diploma of

Ambulance Care and the fourth group are the 'Paramedics' or Advanced Care Officers (ACOs). The paramedic is the highest qualification available, the officer having attained the National Diploma of Ambulance Care. The attainment of each qualification permits the officer to perform a broader range of techniques and administer a wider range of medications.

Ideally ambulances are crewed with a minimum of two persons. This arrangement allows one officer to drive the vehicle while the other attends to the patient(s). On occasions the ambulance will be crewed with only one qualified person, although there may be as many as three crew in any one vehicle. The 'first officer' as recorded on the Ambulance Patient Report should be the officer with the highest qualification who is responsible for administering the patient care. The 'second officer' is the next highest ranked officer, and the third may be a volunteer. Volunteers may include lay persons with the desire to train as ambulance officers; nursing students; registered nurses; or ambulance officers who are not currently employed to work as regular ambulance staff. Qualified paramedics assuming the role of volunteers are only able to work to the level of ICO. (S. Childs, Acting Ambulance Chief, personal communication, 10 February, 1999).

The qualification of the first ambulance officer attending trauma victims included in the study was recorded on the data collection form. In addition, it was noted if there was a paramedic involved in the care of the trauma victim. This information was collected in order to determine if ambulances were suitably crewed or if there was a perceived need for more highly qualified staff in a particular area.

3.4 Documentation in Trauma Fatalities

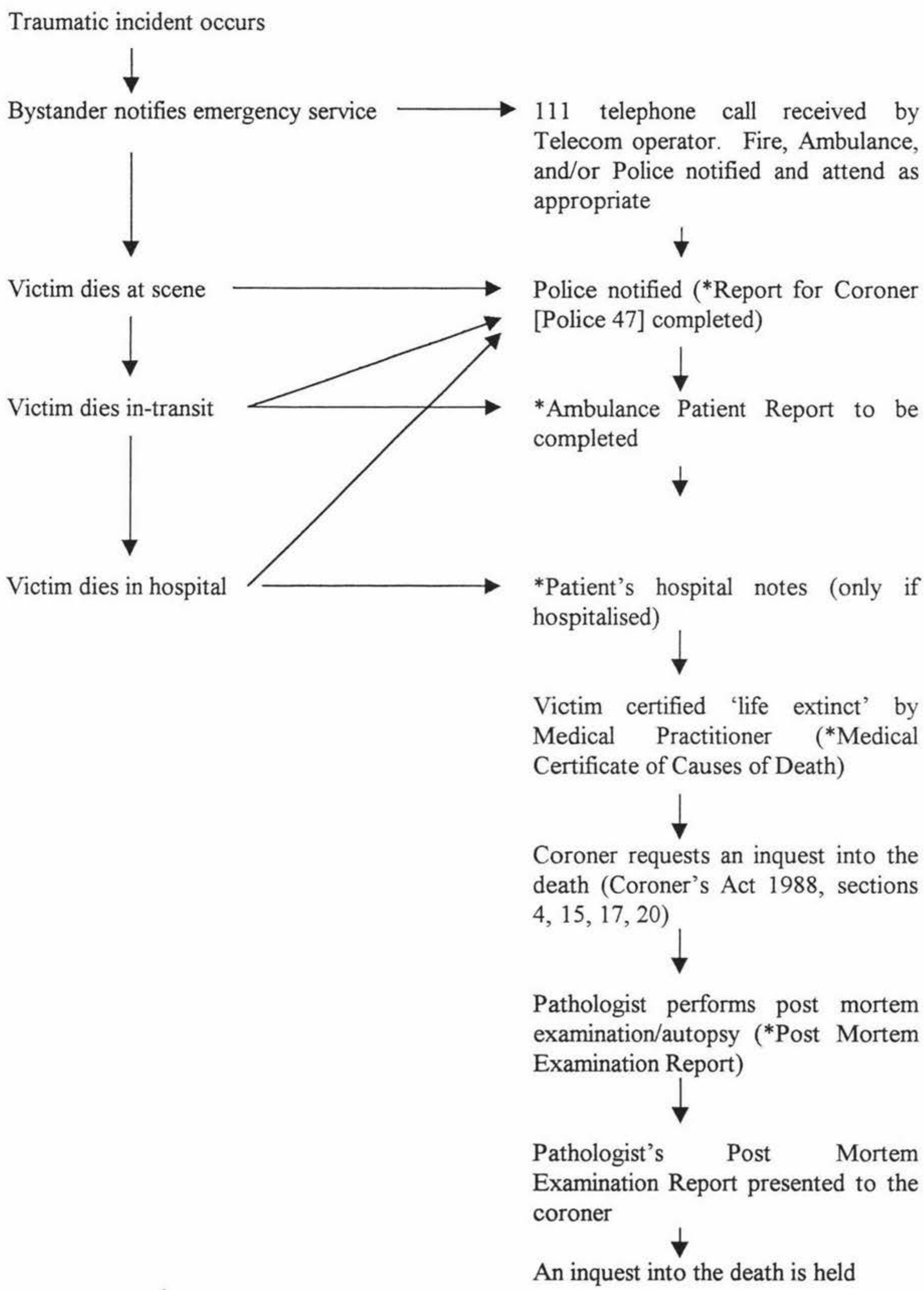
Relevant documents used in the study are presented in Figure 3.2 (see p. 38). The place and time of death determines the amount and breadth of information available on each of the deceased. Reports such as the Report for Coroner ('Police 47'), Ambulance Control Room information, Ambulance Patient Report and patient hospital notes are cumulative, dependent on the location of death. For example, a victim who dies at the scene may receive only a 'Police 47' and a post mortem examination report (autopsy report). A victim who survives the initial insult will receive an ambulance patient report (if treated by ambulance officers), patient hospital notes (following treatment through the various hospital departments), a 'Police 47' and an autopsy report. The data used in the present study was collected from documents routinely received following a trauma death. These documents are now described.

3.4.1 The Report for the Coroner ('Police 47')

All persons who die as a result of a trauma have a 'Report For Coroner' known as the 'Police 47' (see Appendix Two) completed following their death. Briefly, the Police 47 outlines the name of the victim, their race, occupation, the time and place of death and includes a summary of the incident.

In the case of a motor vehicle incident, the report summary should provide information such as the estimated speed of the vehicle at the time of the incident, whether it was the causal vehicle, and whether the individual concerned was wearing a seat-belt. Additional information taken from the 'Police 47' for the purposes of this study included recording the period of time between when the deceased was last seen alive and when they were found dead. This was recorded in order to evaluate if the time delay between the incident and the arrival of the bystander or the emergency service may have been a significant factor in the death.

Figure 3.2. Relevant documentation in the trauma management process.



Key: * Relevant documentation

3.4.2 Ambulance Patient Report

The St. John ambulance protocol requires that a Ambulance Patient Report (see Appendix Three) is completed on any person attended to by ambulance service personnel (even those who are status 0 – deceased), regardless of whether or not the patient is transported. If the victim dies at the scene, in transit to the hospital, or is transported to the hospital alive, all treatment received by the victim is recorded on the Ambulance Patient Report. Decisions such as those regarding resuscitation, are recorded for auditing purposes.

3.4.3 Patient's hospital notes

Medical information written on a trauma victim after admission to hospital is contained within the patient's hospital notes. The content of these notes will depend on the progress of the patient through the hospital system. Hospital blood alcohol levels (where taken) are included in the laboratory test results.

3.4.4 Medical Certificate of 'Life Extinct'

Following any fatality, the trauma victim must be certified 'life extinct' (deceased) by a medical practitioner. This can be done either at the site of the incident by a registered medical practitioner or in the hospital. Once the person has been certified life extinct, the body may be transported to the local undertaker. However, because an autopsy is legally required for all deaths resulting from trauma, the deceased may then be transferred to the hospital mortuary for the autopsy and once the autopsy is completed, released back to the undertaker.

3.4.5 Post Mortem Examination Reports

A Post Mortem Examination (autopsy) Report is legally required on all trauma victims following a post mortem examination. In the report the pathologist notes the injuries sustained by the victim, what he/she considers to have been the cause of death and, in the pathologists opinion, whether the death was suspicious. The report on the ESR blood alcohol is included as an appendix to the post mortem examination report.

3.5 Inquest into the Death

Following an unnatural death, the Coroner's Act (1988) requires that an inquest into the death is held. Information presented at the inquest includes depositions from witnesses, a statement of identification and the post mortem examination (autopsy) report. Further information may include motor vehicle testing reports, blood alcohol levels, suicide notes, accident plans, maps and photographs. Selected information from the inquest may be accessed by the public (Coroner's Act 1988, Section 25 and 44) unless the death is considered to be suspicious.

3.6 St. John Ambulance - Control Room Information

All relevant information is recorded at the St. John Ambulance Service - Central District control room, Palmerston North, when a bystander calls the ambulance service. Information from the printout on traumatic incidents included in the study was transcribed onto the data collection form. Relevant information includes the following:

- time (24 - hour clock) that the call was received at the control room
- the vehicle number and names of ambulance staff notified of the incident
- time the ambulance was assigned the job
- time ambulance staff were able to respond
- time the incident was located by the ambulance staff, and,
- the time the ambulance transporting the patient left the scene, either with the victim for the hospital, or without the victim if left with police or undertaker.
- if the helicopter was called to attend the incident, even if unable to fly due to weather or other circumstances.

  (Source: St. John Ambulance Central Districts control room daily record).

The control room at Palmerston North receives calls for the Ruapehu, Rangitikei, Wanganui, Manawatu, Horowhenua and Tararua districts. Information regarding the trauma is then relayed to the appropriate ambulance station (see Appendix Four). Although the Central Districts Ambulance Service receives calls for the entire central district, the patient catchment area for Palmerston North Hospital is the MidCentral Health primary client community (see Appendix Four for a map of the region).

The primary client community encompasses the area in the lower central districts region along the Southern and Eastern boundaries of the North Island. However, any incidents that occur along the west coast of the central districts region from Tangimoana Northward to Mangaweka and on the Western side of the Rangitikei River are covered by Wanganui Hospital and associated services. The Central Districts St. John Ambulance staff, Palmerston North regional police and Palmerston North Hospital personnel respond to incidents that occur on the Eastern side of the Rangitikei River.

The destination of the patient is determined either in the control room by the person receiving the call, by the ambulance officer treating the person, or by medical personnel on board the ambulance/helicopter. The ACC contractual agreement stipulates that the ambulance service deliver the patient to the most appropriate medical facility. If practical, patient or family requests are taken into consideration (Administration Officer, St. John Ambulance Central Districts, Palmerston North, personal communication, March, 1999).

3.7 Process of Data Collection Used in the Study

Notification of each death due to trauma was conveyed by facsimile sent from the Palmerston North Hospital mortuary assistant on a customised form (refer Appendix Five). Data on the form consisted of the date of the autopsy and the autopsy number of the trauma victim. Minimal information was provided to ensure confidentiality. To ensure capture of all incidents, the researcher also conducted a weekly round of the hospital. This round encompassed visits to the emergency department, the mortuary, the pathology department, the ambulance station, the St. John Ambulance Regional Control Centre, the intensive care unit and, when relevant, a visit to the Palmerston North Hospital police officer. Although time-consuming, these procedures ensured that all victims meeting the inclusion criteria were identified, and through a series of cross-checks (as explained below) every trauma death was included. Further, the establishment of sound working relationships with agencies involved in the trauma management system ensured that the year-long process of data collection was completed in full.

Three registers held in the emergency department were reviewed. These were the 'Dead On Arrival' (DOA)/ 'Death in the Department Book'; the 'Trauma Book' (where all trauma calls are registered); and the Emergency Department 'Daily Attendance Register'. Information sought from the daily attendance register included the names of all 'triage code 1' patients (required to be seen by a medical officer immediately) and 'triage code 2' patients (to be seen by a medical officer within 10 minutes), (see Appendix Six) attending the emergency department following a traumatic injury. The names of these patients were then entered into the Patient Information Management System (PIMS) computer database to ascertain eligibility for inclusion in the study. This process ensured identification of individuals who did not undergo an autopsy; identified cases where the mortuary assistant was unsure whether the individual met criteria for inclusion in the study; and, picked up cases when a patient was transferred to another hospital and subsequently died there.

A further measure to ensure capture of all subjects was done by regular review of both the pathology department 'Post Mortem Register' and the corresponding mortuary 'Post Mortem Register'. These two registers contain information on the date of the post mortem examination; name of the deceased; whether the post mortem examination was conducted as a hospital or Coroner's case; and, the cause of death. By reviewing the cause of death for all of the Coroners' post mortems in the region, it was established whether the death occurred as a result of a traumatic incident and, therefore, met the criteria for inclusion in the study.

The visit to the mortuary enabled the name of the deceased to be matched with the post mortem number. Information was transcribed onto the customised data collection form (see Appendix Seven) from the 'Police 47', post mortem examination reports and ESR documents on blood alcohol levels (where taken) obtained from the pathology department. Information from Ambulance Patient Reports was collected from the ambulance station while the St. John Ambulance Control Centre was visited to obtain information on the telephone call received regarding the incident.

The Intensive Care Unit (ICU) was used informally as a venue for review of the care received by those patients who died in the ICU or passed through the ICU prior to transfer to another hospital. Clinical staff were aware and supportive of the research and were helpful in identifying trauma patients admitted to ICU who were subsequently transferred to another hospital due to the nature of their injuries. This also assisted in ensuring completeness and integrity of the data set.

Patients' notes on those persons who died after arrival in hospital were obtained for information on in-hospital care, operations performed and the hospital blood alcohol level on admission into the emergency department (where taken). Information obtained from the patient's hospital notes included notes written by medical staff (and nursing staff where relevant) within the emergency department, intensive care unit or operating theatre. Radiology reports - including Computed Tomography (CT scan), where performed, and laboratory results were also analysed. The clinical notes of individuals who died in Palmerston North Hospital, or were transferred out and the subsequently died in other hospitals were reviewed for possible complications of care.

The data collection period began on July 1st, 1998 and ran through to June 30th, 1999. The first case meeting the study criteria was included one week after the collection period commenced and the last case was included two days before the data collection period ended. There were no cases where the incident overlapped either the beginning or the end of the data collection period. Most deaths occurred within a matter of hours or days after the event. The two exceptions were a victim who was hospitalised in Palmerston North Hospital ICU for 13 days before the death occurred, and another patient who was transferred out to a tertiary hospital and died 17 days post-incident. The total number of trauma deaths anticipated for the year was 100. The actual number obtained was 61. Five of these cases were excluded from the trauma death population as their traumatic injuries were found to have been secondary to medical problems. After a review of the annual total of Coroner's deaths for the previous 10 years, the total of 56 trauma deaths obtained was fairly indicative of the annual average.

3.8 Gaining Approval for Access to Information

Between January to June 1998, when the research topic was being finalised, relevant personnel were contacted to obtain permission to access information for the study. Personnel included the five regional coroners located in Palmerston North, Feilding, Marton, Dannevirke and Levin, as well as the Taihape coroner. The Taihape Coroner usually sends trauma victims to Wanganui Hospital for an autopsy unless the Wanganui pathologist is overloaded or unavailable. In the case of forensic pathology (for suspicious deaths), cases are sent to the Palmerston North Hospital mortuary for an autopsy.

The Area Manager for St. John Ambulance Service - Central Districts and the Central Districts Manager for the police were contacted and approval sought to gain access to information on all deaths in the region due to trauma. The four Palmerston North Hospital pathologists were contacted with regard to the research. Company approval was sought from MidCentral Health Acute Services Manager following approval for the research from the Whanganui-Manawatu Ethics Committee. The Director of the Palmerston North Hospital Intensive Care Unit consented to assist in the study where care provided by medical staff in the ICU was to be analysed.

3.9 Evaluation of Patient Management and Classification of Death

A panel of specialists from throughout New Zealand who were known to have an interest in trauma management, were invited to evaluate the management of selected trauma victims and classify the deaths. The expert panel was chosen after a review of the literature and a multi-disciplinary panel was decided upon. Although, two expert panels each independently evaluating the cases would have been preferred, the trauma death population was not sufficient to justify this and the logistics of doing so were prohibitive. Each panel member was independently selected because of their expertise in the various field and, with the exception of the paramedic, due to their employment status as a specialist external to the environment under evaluation. The director of the St. John Ambulance Service – Central District attained his position after completion of the data collection phase. The paramedic was chosen specifically because of her local knowledge and direct involvement with a large number of the cases being evaluated. Due to the 3:1 ratio of rural to urban trauma deaths, it was felt that the inside pre-hospital knowledge of the paramedic would be advantageous.

The expert panel consisted of a general/vascular surgeon – the director of trauma services for the Auckland Region. A neurosurgeon; an intensive care specialist also employed as the director of the St. John Ambulance Service – Central Districts; an emergency department medical specialist; and, a paramedic were included.

The data set included 56 persons representing a census of trauma deaths in the greater Manawatu region from 1 July 1998 to 30 June 1999. There were 11 individuals who were found dead at the scene of the incident and whose care did not involve the ambulance service. These cases were excluded from the panel review process as they did not provide an opportunity for any part of the trauma system to be evaluated. A further 25 cases were excluded from the main panel evaluation process as they were found to be 'in cardiac arrest' (dead) at the scene of the incident. However, the director of ambulance services/intensivist and the paramedic on the panel did review these 25 cases where the ambulance service were notified of, and responded to, the incident. The evaluation of this group of 25 was done in order to evaluate the time management of dispatch of the appliance and the location of the patient.

The main group of victims for the full evaluation, therefore, totalled 20 cases. The entire panel evaluated the management of these 20 trauma victims and classified their deaths in terms of preventability. The group of 20 included five trauma victims who were 'not in cardiac arrest' at the scene of the incident but died after the arrival of ambulance officers; one person who died in-transit to hospital; and, 14 who died as hospital in-patients.

Each panel member was provided with a full set of notes (an average of 25 pages for each case) on the 20 cases being evaluated. The notes, where available, consisted of the Regional Control Centre (RCC) information on ambulance dispatch and location times and ensuing text; the Ambulance Patient Report; The 'Police 47' (Report for Coroner); the Post Mortem Examination Report (autopsy report); and, the blood alcohol level, either hospital or ESR. The in-hospital information included any or all of the following: The emergency department resuscitation flow sheet; CT scan report; operating theatre notes; ICU charts, medical and nursing notes; radiology reports; and, laboratory results. Any other relevant information was also attached.

Information on the 20 cases (with the additional 25 cases for review of the ambulance service) was presented to the panel members in a non-blinded format for an independent evaluation of the cases. The panel members were asked to assess each case (within their capacity) and classify the death using a four-point scale. The four options included the classifications of 'preventable', 'possibly preventable', 'not preventable' or 'undecided' (insufficient information available/or not within the panel member's area of expertise). The panel were asked to evaluate the cases using the following documents:

1. *'Classification of death'* by McDermott et al. (1997).
2. *'Definition of problem categories'* (guidelines) by McDermott et al. (1997).
3. *'Outcome questions answered for each case'*, by Maio et al. (1996) (refer Appendix Eight).

The panel members were asked to address three main issues:

1. Did personnel who were involved in the management of the patient follow the appropriate procedures within the trauma system?
2. Did personnel provide adequate clinical care?
3. Was the management of each deceased person optimal and if not, was their death preventable or possibly preventable?

After an independent assessment of the cases by each member the expert panel met for one day as a group. The meeting was chaired by the author with assistance from the principal supervisor and the second supervisor. The decision rule of panel consensus was employed. The classification of death reflected the consensus of the panel or the majority of opinion if no consensus was reached. The objectives of the one-day group panel meeting included addressing issues such as:

1. Was the length of time between the incident and arrival of emergency service personnel relevant in terms of patient survival ('the Golden Hour' theory)?
2. Are ambulances suitably crewed for the area and the population of casualties?
3. Is the appropriate form of transportation being used for trauma victims?
4. Are the Palmerston North Hospital trauma team guidelines satisfactory and applicable, and if not, why not?
5. Was the patient transferred to the appropriate hospital in a timely fashion?
6. Are there any deficiencies in the trauma management system?

The following documentation was available for panel members to use in order to evaluate the management of trauma patients as per the current protocols:

1. *'Guidelines: For A Structured Approach To The Provision Of Optimal Trauma Care, Trauma Project For The Ministry Of Health'* (Royal Australasian College of Surgeons - New Zealand Trauma Committee. May, 1994).
2. Palmerston North Hospital EMT guidelines titled *'Early Management of Trauma: 8^{th} edition, 2000'* (Hicks & McKenzie, 1999).
3. *'Patient Care Procedures and* Notes' (1999). Ambulance Education Council. Paramedic and Non-Paramedic manuals.
4. Palmerston North Hospital Intensive Care Unit procedures for example, protocols on *'Head Injury Management'* and *'Intracranial Pressure Monitoring'*.

3.10 Summary

The data collection process used in the study has been described. A flow chart outlining the progress of a traumatic incident was included, refer to Figure 3.1. The numerous documents used by the agencies throughout the trauma management system were reviewed. The relationship between the various agencies and the flow of information was also depicted in Figure 3.1.

The chapter concludes with an explanation of the process used by the expert panel to evaluate the patient management and classification of death for various cases from the trauma death population. These include 25 cases where the ambulance service was notified of the incident and responded, only to find that the person was dead on arrival. The second group of 20 was fully evaluated by all of the five panel members. This group included those persons who were treated by various personnel in the trauma system and either died at the scene, died in transit, or died in hospital.

CHAPTER FOUR: FINDINGS

4.1 Introduction

In the twelve months from July 1st, 1998 to June 30th 1999, 61 deaths apparently resulting from trauma occurred in the study region. Five of these 61 patients were subsequently excluded from the study as all were considered to have received the traumatic injury secondary to the initial insult. The remaining 56 cases included two persons whose injuries were received while in the study region but who subsequently died outside of the region, and a further three patients who died outside the region and were transferred into the region for the purposes of autopsy.

Of the five cases excluded from the study, the cause of death in two cases was determined to be due to an intracerebral bleed and was followed by a fall; two cases were found to have died as a result of coronary artery insufficiency and then suffered a fall; and, one case was excluded after having been found to have drowned at sea and then suffered a degloving injury. This chapter reports on the trauma death population of the 56 cases.

Two cases were transferred out of the Palmerston North region for specialist care in tertiary hospitals. These included one motor vehicle accident victim who was transferred from Palmerston North Hospital to Burwood Hospital, Christchurch for management of spinal injuries. From there the patient was transferred to Christchurch Public Hospital for airway management and ventilation where the victim subsequently died. The second individual suffered burns to 90% of the Total Body Surface Area (TBSA). The burns patient was transferred from Palmerston North Hospital to Wellington Public Hospital and then to Middlemore Hospital, Auckland for further debriding and skin grafts to the burns. The patient subsequently died in Middlemore Hospital.

Three individuals died outside the region and were transferred to Palmerston North Hospital for autopsies. All of the transfers came from the Wanganui Region. One transfer occurred because the Wanganui pathologist was unavailable to perform the autopsy. The other two cases were performed by a Palmerston North pathologist for forensic pathology.

Trauma deaths are described according to the demographic profile of the trauma death population; geographical location of the deaths and the location of the deaths in respect to the trauma system. The categories of death and an outline of the number of victims and type of trauma that resulted in the death (blunt, penetrating injury or burns) is also presented.

4.2 Sources of Data and Population Demographics

Data on the 56 cases were collected from the following sources: Ambulance Patient Reports; 'Police 47s' (Reports for the Coroner); post mortem (autopsy) examination reports; and, ambulance control room records. Environmental Science and Research Institute (ESR) blood alcohol assays were taken from 34 victims. Hospital blood alcohol assays were taken from two cases and 20 cases did not have blood samples taken for either ESR or hospital blood alcohol levels. Blood alcohol assays were taken on all motor vehicle related fatalities for the purpose of the study, but not on the total population. The number of reports and type of reports available is shown in Table 4.1.

Table 4.1. Documentation available for the 56 trauma death cases.

Documentation	Number available	Percentage
Ambulance Patient Reports	35	62.5
'Police 47' (Report for Coroner)	54	96.4
Autopsy Report	54	96.4
ESR Blood alcohol level	34	60.7
Hospital Blood alcohol level	2	3.5

An autopsy was performed on 54 of the 56 cases. The autopsy of one subject, however, was restricted to an external observation subsequent to a discussion with the Coroner. This person was known to have had close contact with an individual who had recently died from Creutzfeld-Jacob Disease and the potential risk of performing a full autopsy was, therefore, too great for a full examination to be carried out. Two subjects did not undergo an autopsy. One of these subjects was the victim of a car versus train incident. In this case the regional Coroner was on vacation and a Justice of the Peace (JP) was holding office. It appears that the JP was unaware that an autopsy was required and accepted instead, the cause of death stated on the medical certificate (personal communication, P. Comber, 20th March 1999). The second case involved a suicide by gunshot to the head. The injuries incurred by this person were such that half of the head was removed. The Coroner determined that the cause of death in this case was obvious and that the circumstances were not suspicious.

A total of 12 of the 54 cases that had an autopsy excluded an examination of the head. These 12 fatalities included: one suicide by laceration of the neck and wrists; one motorcycle incident; one death by electrocution; two motor vehicle incident deaths; one gunshot wound to the head; and, six cases where death was determined to be a result of hanging. The inclusion/exclusion of body regions (particularly the head) in an autopsy examination, appears to be at the discretion of the pathologist. The primary function of the autopsy examination is to establish *'a'* plausible cause of death in the opinion of the operating pathologist.

The average age of the subjects was 36.0 years (range 1 to 82 years), of whom 41 individuals were under the age of 45 years. There were 34 males (60.7 %) and 22 females (39.2%). Males exceeded females in every age bracket up to 64 years, thereafter, females exceeded males. Figure 4.1 shows the age and sex distribution of the population.

There were 40 Caucasians, 14 Maori, one person of full Fijian extraction and one person who was classified as part Fijian as seen in Figure 4.2.

Figure 4.1 Age distribution and sex of trauma cases

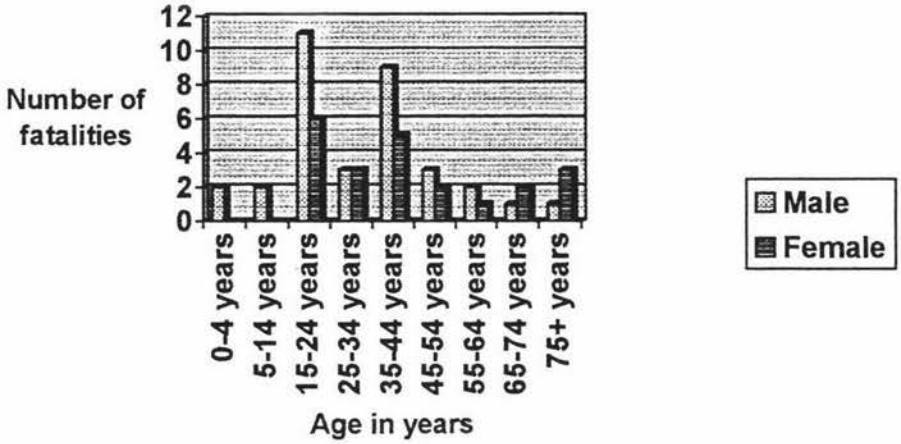
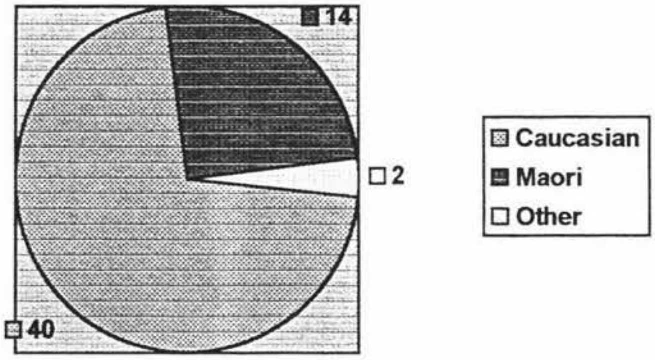


Figure 4.2 Ethnic origin of trauma cases



4.3 Description of Deaths

The geographical location of the deaths is presented in a map of the region and the location of incidents identified. This is followed by a flow diagram which tracks the trauma death population through the various stages of the trauma system. The section concludes with a diagrammatic representation of the duration of survival for the population post-incident.

4.3.1 Location of traumatic incidents

A total of 42 incidents (75%) leading to the deaths occurred in a rural setting and 14 (25%) incidents occurred in a built-up area. The location of traumatic incidents for the population is shown geographically on a map of the region (refer to Appendix Nine – map of fatalities).

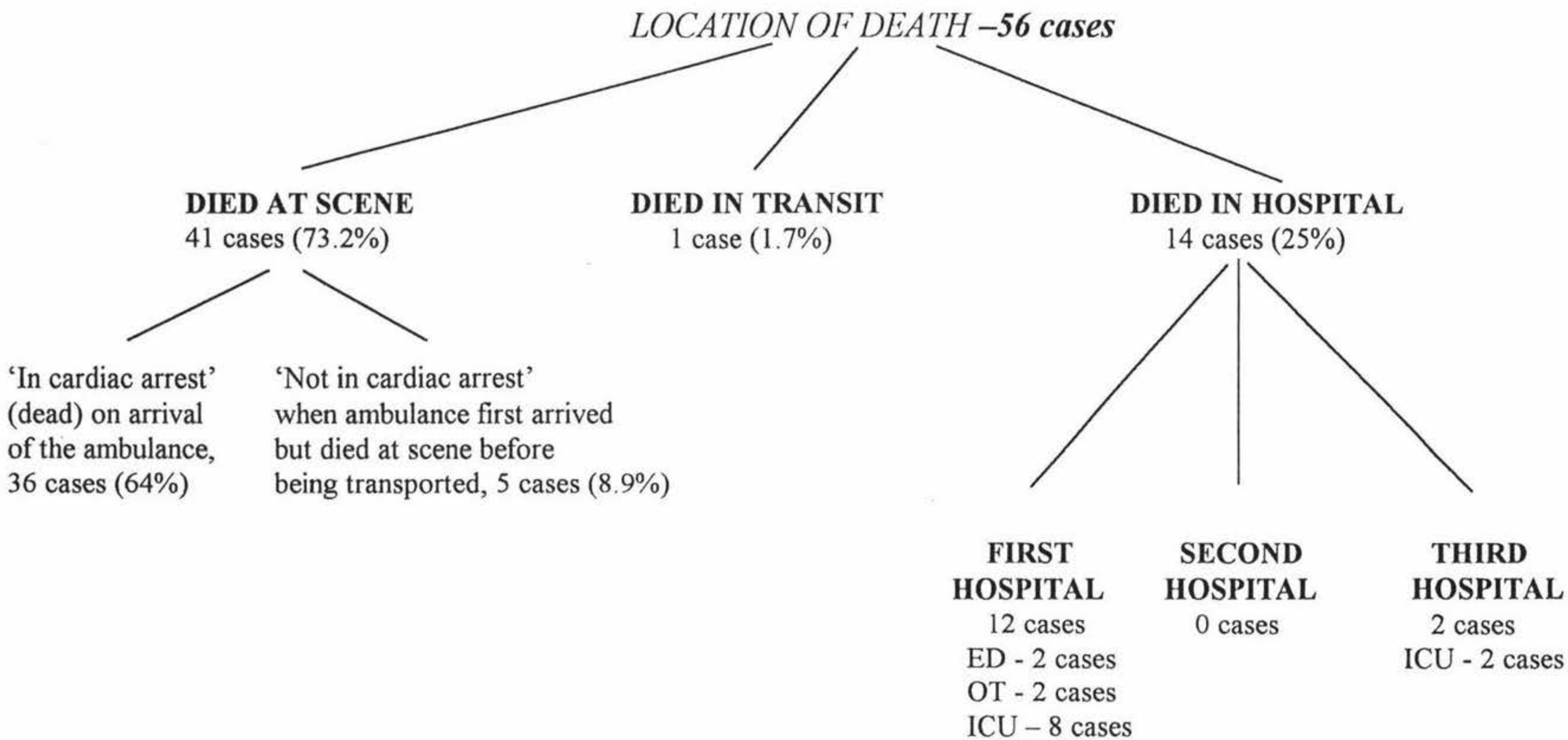
4.3.2 Location of death

A total of 41 persons died at the scene of the incident. Of these, 36 were found 'in cardiac arrest' (pulseless, apnoeic and unconscious) at the scene of the incident on arrival of the ambulance service. A further five cases were 'not in cardiac arrest' on arrival of the ambulance service but died at the scene after the arrival of the service. One person died in transit to hospital and 14 people died after being hospitalised, as shown in Figure 4.3.

4.3.3 Duration of survival post injury

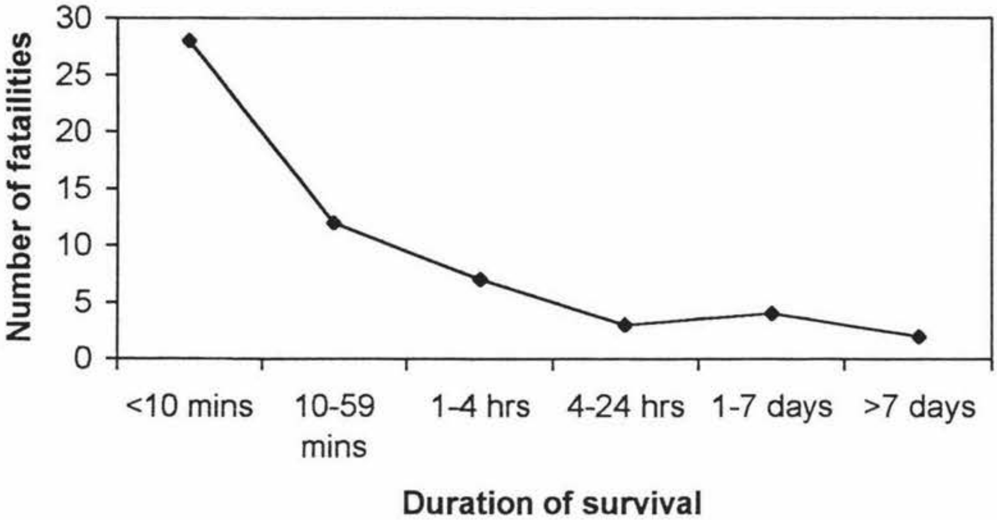
The duration of survival ranged from less than 10 minutes to 17 days, presented in Figure 4.4 (p. 55). A total of 28 individuals (50%) were calculated to have survived less than 10 minutes post-incident and 12 individuals (21.4%) survived for less than one hour giving a total of 40 (71.4%) who did not survive the first hour post-trauma (the golden hour). Seven (12.5%) persons survived between one and four hours and three (5.3%) between four and 24 hours. Only 6 people (10.7%) survived for longer than 24 hours. Four of whom died within one to seven days and two who survived for more than seven days.

Figure 4.3. Location of death for the population of 56 trauma fatalities.



Key: ED = Emergency Department; OT = Operating Theatre; ICU = Intensive Care Unit

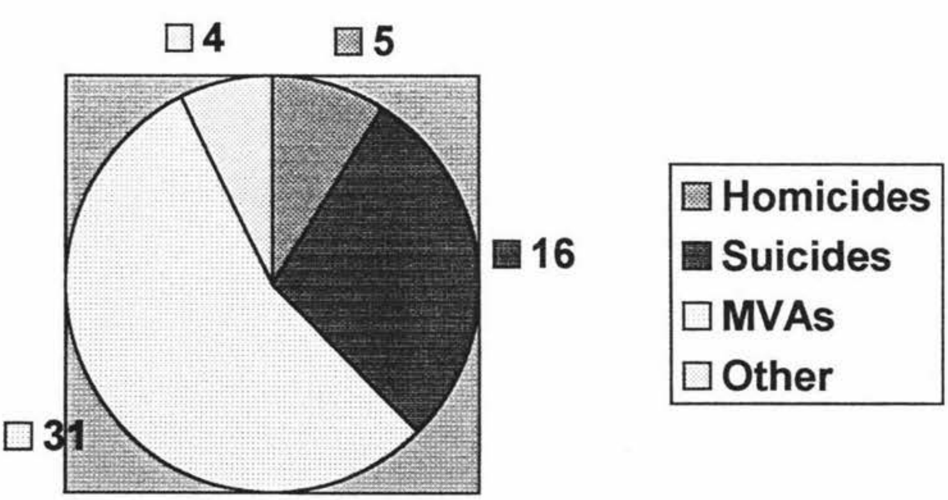
Figure 4.4 Duration of survival post-incident.



4.4 Category of Trauma

The number of deaths by category of trauma such as road crashes, suicides, homicides and 'other' causes of death are presented in Figure 4.5, and described below.

Figure 4.5 Distribution of fatalities by category of trauma.



There were 31 (55.3%) road crash victims from the population of trauma deaths. These comprised 23 (41%) car occupants; three incidents which involved trains; five motorcyclists (8.9%); one of which was a motor scooter rider; one truck driver (1.7%); one bus passenger (1.7%); and, one intoxicated pedestrian (1.7%) who was hit by a car.

There were 16 deaths (28.5%) that were thought to be a result of suicide. Of these 10 were due to hanging (17.8%); four were gunshot wounds (7.1%); one was a pedestrian who jumped into the path of an oncoming truck and trailer unit (1.7%); and, one person slashed both wrists and neck (1.7%).

There were five homicidal deaths (8.9%). Three deaths were due to stabbing or slashing (5.3%). There was one accidental shooting (1.7%), and one cyclist who was a victim of a hit and run incident (1.7%).

Other causes of death included one fall (1.7%); one electrocution (1.7%); one burn (1.7%) and, one drowning following a head injury (1.7%).

4.4.1 Blunt and penetrating trauma

Blunt trauma accounted for 45 deaths (82.1%), and penetrating wounds accounted for ten deaths (16%). One case died after receiving extensive burns (1.7%). The distribution of blunt and penetrating trauma deaths is shown in Table 4.2.

Table 4.2. Fatalities related to type of trauma.

Type of Trauma	Number of Instances	Total and Percentages
Blunt Trauma		45 (80.3%)
Road crashes	30	
Falls	1	
Other*	14	
Penetrating Trauma		10 (17.8%)
Stabbing/ slashing	4	
Gunshot wounds	5	
Electrocution	1	1 (1.7%)
Burns	1	1 (1.7%)
Total		56 (100%)

Key: *Other includes one pedestrian hit by a car (unintentional by pedestrian); one pedestrian hit by a truck and trailer unit (intentional by pedestrian); one head injury/drowning victim; and, one hit and run bicyclist. There were also 10 (other) persons who committed suicide by hanging.

4.5 Pre-Incident Factors Contributing to the Deaths

Pre-incident factors may also influence the fatal outcome of traumatic incidents. The pre-incident factors that had relevance to the 56 cases included in the present study were: a positive blood alcohol level; inappropriate speed where the incident involved a motor vehicle; and, any omission of safety equipment or safety practice which may have contributed to the death. The two other pre-incident factors which were relevant in some of the cases, included a significant co-morbidity (existing medical condition, for example, ischaemic heart disease or a psychiatric history) and old age.

4.5.1 Alcohol

ESR blood alcohol assays were taken on 34 cases; however, the result of the blood alcohol level was not available in the case of one homicide. Hospital blood alcohol assays were collected on a further two cases. Neither the ESR nor hospital blood alcohol levels were available in 20 cases: of these, two victims were under the age of five and in one case there was insufficient blood available for the assay.

The current legal drink-driving blood alcohol limit in New Zealand is 80 milligrams of alcohol per 100 millilitres of blood. Of the nine cases with positive blood alcohol levels there were three car drivers; one rear-seat car passenger; three motorcyclists (two riders and one pillion passenger); one pedestrian who was hit by a car; and, one death which was the result of hanging (low blood alcohol). Table 4.3 shows the mechanism of injury and blood alcohol level of the nine alcohol positive victims.

Table 4.3. Positive blood alcohol levels (milligrams of alcohol per 100 millilitres of blood) and mechanism of injury.

Blood alcohol level	Mechanism of injury
30	Suicide – hanging
63	MVA – single car
92	MBA – rider (causal vehicle)
126	MVA – driver (causal vehicle)
137	MBA – pillion
168	MVA – rear seat passenger
194	Intoxicated pedestrian
259	MVA – single car
274	MBA – rider (causal vehicle)

Key: MVA : Motor Vehicle Accident
MBA: Motorbike Accident

All but one of the deaths presented in Table 4.3, a suicide, was the result of a motor vehicle related incident. In total there were 31 incidents involving a motor vehicle (excluding the intentional suicide victim who was hit by a truck and trailer unit). Of these 31 motor vehicle related incidents, eight persons had been drinking alcohol, and only one of these had a blood alcohol level below the legal driving limit. As there were three persons in motor vehicle related incidents who did not have a blood sample taken for an alcohol assay, it is unknown, therefore, if alcohol was a contributing factor in *more* of the deaths.

The 33 ESR blood results showed that 24 of the 33 cases (72.7%) where a blood alcohol assay was taken had a 'negative' (0) blood alcohol level, while positive blood alcohol levels were recorded in nine (27%) of the cases. Two of the nine cases had blood alcohol levels that were less than 80 milligrams per 100 millilitres; five cases had levels that ranged between 80 and 200 milligrams; and, two cases had blood alcohol levels that were between 200 and 300 milligrams per 100 millilitres. The two hospital blood alcohol levels were recorded at one millimol per 100 millilitres (0.2 milligrams per 100 millilitres) and 11.32 millimols per 100 millilitres (2.4 milligrams per 100 millilitres). Both of the hospital blood alcohol levels are insignificant in terms of contributing pre-incident factors.

4.5.2 Road crash victims

Data available on speed and safety practices with both vehicular and non-vehicular accidents is now described.

Speed in motor vehicle incidents

The significance of speed as a contributing factor to the death has been presented in this section in two ways. The speed that the victim was travelling (where known) has been recorded. In addition, where speed was a contributing factor to the death by the offending party involved in the incident (in many cases a survivor), this has been also been identified. Information on speed was not always documented on either the 'Police 47' or the Ambulance Patient Report: in seven of the 31 road crash fatalities the speed of the vehicle was not recorded.

Low speed was a factor in the death of one case where the driver of a car performed a 'U' turn on a main highway. The victim was 'T-boned' (hit in a perpendicular fashion) by an oncoming car. It was noted that the colour of the approaching car, a grey/blue, was possibly a contributing factor in the death as the colour made visibility of the vehicle difficult. The speed was recorded as 'medium' in eight incidents. In five of these incidents, failure to heed 'Give Way' or 'Stop' signs and crossing the centre line, were recognised as contributing factors to the deaths.

High speed was recorded in thirteen incidents. 'Excessive' speed was a causative factor in two deaths: One of these two incidents involved speeds of 150 kilometres per hour in an area that was restricted to a 30 km per hour limit because the road was being re-sealed, the blood alcohol level for this person was recorded at 259 milligrams of alcohol per 100 millilitres. The second incident involved a motorcyclist who failed to take a bend in the road and collided with a van head-on. The motorcyclist's speed was estimated at to be 'at least 155 km per hour' while travelling in a 50 km per hour zone. The blood alcohol level for this individual was recorded at 274 milligrams of alcohol per 100 millilitres of blood.

Safety practices and use of safety equipment on roads

Under New Zealand law seat-belts must be worn by all occupants of a car. Despite the law seven of the motor vehicle related trauma deaths were recorded to be without seat-belts (23.3%), the remaining five car occupants (16.6%) from the road crash population of 30 persons (the intoxicated pedestrian who was hit by a car has been excluded from this analysis) were known to be wearing their seat-belts. In 13 cases information on the use of seat-belts is unknown (the remaining five persons were travelling on motorcycles). Although the seat-belt use of both the truck driver and the bus passenger were not documented, for the purposes of this analysis as based on common practice, both cases have been recorded as not wearing seat-belts. This gives a total of nine persons recorded without seat-belts, and 13 persons for whom this was not recorded.

Five motorcyclists (including one motor scooter rider) were included in the study. Of these five, three cases were known to be wearing a helmet (60%), one was known to be without a helmet (20%) and in one case it was not stated. One motorcyclist was noted to have crossed the centre line and was then hit by an oncoming car. The bicyclist was wearing a helmet.

Road safety was compromised in eight incidents. Two of the three motor vehicles crashes involving trains were the result of the victim failing to heed both warning bells and flashing lights at the rail crossing. The third death occurred on a 'private crossing' which is not sign posted, nor flanked by lights or bells. Barrier arms, as recorded on the 'Police 47', were absent at all three crossings.

Failure to keep to the appropriate lane and crossing the centre line cost the lives of three car occupants and three motorcycle riders, one of which was a pillion passenger. Failure to 'stop' or failure to 'give way' at an intersection resulted in five deaths. Table 4.4 shows a distinctive pattern of positive blood alcohol levels; inappropriate speed; poor safety practices; and, omission of the use of safety equipment on roads: the demographics of age and sex are included.

Although the screening of illicit drugs was not included in the study methodology, two of the motorbike victims had blood screened for the presence of cannabis metabolites, cocaine, amphetamines and morphine. The cannabis screen returned a positive result in both of these cases. On the ESR results for these two persons, the toxicologist stated that "blood levels are a poor indicator of cannabis intoxication. It is not generally possible to determine whether a subject was intoxicated from blood levels alone. However, at the levels detected in [these] case(s) it is likely that [these] person(s) were affected by cannabis at the time of death" (S. Dickson, personal communication, 17 June, 1999). The toxicologist further commented that the use of cannabis with alcohol tends to accentuate the effect of the alcohol.

Table 4.4. Positive blood alcohol levels, speed, safety practices and equipment usage cross-classified with victim demographics for road fatalities

Case no.	Age and sex	Status and causal vehicle	Blood alc. level[1]	Speed (km/h) where known	Safety eqpt usage	Safety practices	Cause of death
39	24 F	Driver, car (Yes)	63	High	Seat-belt use unknown	Unknown	Multiple injuries
51	38 M	MBA, rider (Yes)	*92	At least 100 km/hr	Helmet worn	Crossed centre line	Multiple injuries
44	38 F	Driver, car (Yes)	126	Unknown	Unknown	Crossed centre line	Multiple injuries
50	36 M	MBA, pillion (N/A)	*137	At least 100 km/hr	No helmet	N/A	Injury to thoracic aorta
35	19 F	Passenger, car (N/A)	168	High	No seat-belt	Sitting on knees of rear seat passenger	Multiple injuries
54	36 M	Pedestrian hit by van (N/A)	194	High speed impact 100 km/hr		Wearing black, walking in middle of road at night	Multiple injuries
37	47 M	Driver, car (Yes)	259	150 km/hr	No seat-belt	Temporary 30 km/hr zone	Head injury
42	21 M	MBA, rider (Yes)	274	155 km/hr in 50 km/hr zone	Helmet worn	Unknown	Cardiac injury

Key: M = male; F = female; MBA = Motorbike Accident;
N/A = Not applicable; eqpt = equipment

Note: [1] Blood alcohol levels are in milligrams of alcohol per 100 millilitres of blood
* Tested for cannabis metabolites. Results in both cases state positive cannabis intoxication at the time of death. In addition, the use of cannabis with alcohol tends to accentuate the effect of the alcohol.

Non-vehicular safety practices

Documentation from the 'Police 47' on the electrocution victim states that "power (to the pump being repaired) was supplied by a series of extension cords (eight in total) from an exterior hotpoint on the house. The cords were in very poor repair and all plugs completely exposed to the elements". One other death in the study was known to be the result of the person smoking in a garage in close proximity to highly combustable solvents, the victim suffered burns to 90% of the body.

4.5.3 Co-morbidity

Persons with known medical co-morbidity included: one individual with a kidney tumour; two individuals with Ischaemic Heart Disease (IHD); one person with hypertension; and, three persons with Chronic Obstructive Respiratory Disease (CORD). Of these co-morbidities one person suffered from all three conditions of CORD, IHD and oesteoarthritis. The presence of an existing medical condition, such as IHD or CORD are recognised as potential contributing factors to death following a traumatic incident. The victim with a co-morbidity will have the initial insult to recover from, which may not have a high ISS/NISS score. However, the pre-existing condition will, in the majority of cases, hinder the recovery process and decrease the chance of survival.

Solvent abuse was a factor in the deaths of two teenagers. Further, the majority of victims who died as a result of suicide had a previous history of mental illness such as depression or border-line personality disorder. Those persons suffering from depression or some other psychiatric condition, who committed suicide, will have been affected by the mental illness, with the resultant suicide attempt possibly stemming from the unsatisfactory management of the condition.

4.6 Post-incident Factors

Post-incident factors that have relevance to trauma death include the number and type of injuries sustained and the grading of each case in terms of the Abbreviated Injury Scale (AIS), the Injury Severity Score (ISS) and the New Injury Severity Score (NISS) where this differs from the original ISS. Grading of injuries using the AIS provides information on the severity of the injury within a body region. Grade 6 and grade 5 injuries often result in an early fatality, i.e., at the scene of the incident. The ISS provides information on the likely effect of the overall insult to the victim, but is well recognised as having some limitations. Due to these limitations, the ISS has recently been updated by the New Injury Severity Score (NISS) which the authors, Osler, Baker & Long (1997) state provides a better predictor of survival outcome (refer to Section 2.5, in Chapter Two).

Also related to survival is the overall function of the trauma management system. Trauma management issues, such as ambulance service response times from notification of the incident through to arrival at hospital; the time taken for intra-hospital transfers and the distance between the location of the incident and arrival of the patient at the appropriate medical facility are described at the end of Section 4.7.

4.6.1 Multiple injuries

Many victims sustained more than one injury to a body region. Injuries to body regions (except some minor lacerations and abrasions – grade 1) were all coded. Even in cases where the body region scored a grade 6 injury (and was therefore awarded an ISS or NISS of 75 - the absolute maximum), all other injuries were coded. In those cases where the death was found to be a result of hanging, but the individual did not undergo an examination of the head as part of the autopsy, neither an AIS nor an ISS code was able to be assigned. One fatality was the result of an electrocution, this case was also unable to be coded. For those individuals who died as a result of hanging and the head was examined at autopsy, the AIS, ISS and NISS were coded. The rationale behind the AIS coding system is that the actual injury and not the consequences of the injury are coded. Therefore, unless the injury was commented on by the pathologist it was not coded (Association for the Advancement of Automotive Medicine: 1990 revision) see Appendix Ten.

The body of one victim was mutilated beyond recognition. The Abbreviated Injury Scale (AIS) 1990 revision manual does not include sufficient grade 6 (maximum) injury codes that correspond to the injuries sustained by this victim, therefore, the coding for this case was very conservative and some injury coding has been omitted.

4.6.2 The Abbreviated Injury Scale (AIS)

The AIS codes are assigned as follows: grade 1 (minor); 2 (moderate); 3 (serious); 4 (severe); 5 (critical) and 6 (maximum) – currently untreatable (see Appendix Ten). Table 4.5 presents information on the total number of injuries for each AIS grade for the population of trauma deaths, the total number of injuries for each region, and the percentage of injuries to the various body regions.

Table 4.5. The number of AIS injuries (total of 310 injuries) by grade for the population of 56 trauma victims.

	Grade						No. of
Region	**6**	**5**	**4**	**3**	**2**	**1**	**injuries (%) total**
Head	4	17	30	21	3	6	**81(26.1)**
Face	0	0	0	0	3	8	**11 (3.5)**
Neck	0	2	0	4	3	2	**11 (3.5)**
Thorax	12	8	26	26	16	6	**94 (30.3)**
Abdomen	1	4	8	10	13	1	**37 (11.9)**
Spine	2	1	1	1	3	0	**8 (2.5)**
Up ext*	0	0	0	3	17	5	**25 (8.0)**
Low ext*	0	0	3	22	8	8	**41 (13.2)**
External	1	0	0	0	0	1	**2 (0.6)**
Total	**20**	**32**	**68**	**87**	**66**	**37**	**310**

Key: Up ext = Upper extremity; Low ext = Lower extremity

As presented in Table 4.5, the total number of injuries far exceeds the number of deaths. Some of the victims sustained more than one injury to a particular body region. Injuries incurred to the thoracic region comprised 30.3% of the total number of injuries for all body regions. This was followed by the head (26.1%), the lower extremities (13.2%) and the abdomen (11.9%). Injuries to the upper and lower extremities were mainly grade 3 (serious) and grade 2 (moderate) injuries. All injuries sustained by the population of trauma deaths and the AIS codes for each person are presented in Appendix Eleven.

The AIS grade 6 (maximum) and grade 5 (critical) injuries to all nine body regions identified in the AIS classification, and incurred by the population of trauma death victims, are presented in the following tables (Tables 4.6 – 4.11). Where there are no AIS grade 6 or grade 5 injuries to the particular region the associated table has been omitted. The AIS code for the specific injuries are included in the tables in brackets.

Head region

Of the 56 cases there were four AIS grade 6 (maximum) and 17 grade 5 (critical) injuries to the head region. The total number of injuries received to the head region for the total population was 81 (26.1%). The actual injuries sustained are described in Table 4.6.

Table 4.6. Number and type of injury incurred and the AIS code (in brackets) for the head region.

Region: HEAD	**Type of injury incurred and AIS code**	**Number of cases**	**Total no. of injuries for the population**
Grade 6 – maximum	• Massive destruction of cranium and skull – (113000.6) • Brain stem laceration – (140212.6)	3 1	4 grade 6 injuries
Grade 5 – critical	• Severe oedema with absent ventricles – (140674.5) • Penetrating injuries to cerebrum – (140690.5) • Severe brain swelling – (140666.5) • Brain stem contusions – (140204.5)	1 2 10 4	17 grade 5 injuries
			81 (all grades) (26.1%)

Face

Possible AIS grades of facial injuries range from 1 (minor) to 4 (severe). There were no possible grade 5 or 6 injuries for this region among the study population. The total number of facial injuries graded for the study population was 11 (3.5%).

Neck

No AIS grade 6 injuries were coded for this region. There were two cases that received grade 5 (critical) injuries to the neck described in Table 4.7 below. The total number of injuries coded for this region was 11 (3.5%).

Table 4.7. Number and type of injury incurred and the AIS code (in brackets) for the neck region.

Region: NECK	Type of injury incurred and AIS code	Number of cases	Total no. of injuries for the population
Grade 6 – maximum		0	0 grade 6 injuries
Grade 5 – critical	• Massive destruction (transection) to larynx – (340212.5)	2	2 grade 5 injuries
			11 (all grades) (3.5%)

Thorax

There were 12 separate AIS grade 6 (maximum) injuries scored for the thoracic region and eight grade 5 (critical) injuries. A total of 94 (30.3%) injuries were coded from the trauma population for the thoracic region, see Table 4.8.

Table 4.8. Number and type of injury incurred and the AIS code (in brackets) for the thoracic region.

Region: THORAX	Type of injury incurred and AIS code	Number of cases	Total no. of injuries for the population
Grade 6 – maximum	• Major laceration to thoracic aorta with haemorrhage not confined to the mediastium – (420218.6)	7	12 grade 6 injuries
	• Multiple lacerations to the myocardium – (441016.6)	2	
	• Complex lacerations (or ventricular rupture) to the myocardium – (441014.6)	3	
Grade 5 – critical	• Major laceration to the thoracic aorta – (420210.5)	2	8 grade 5 injuries
	• Major thoracic laceration with root or valve involvement – (420212.5)	1	
	• Myocardial laceration – (441012.5)	1	
	• Complex laceration to trachea and main stem bronchus – (442610.5)	1	
	• Major fracture of trachea and main stem bronchus with laryngeal-tracheal separation – (442616.5)	1	
	• Fractured ribs (more than three on both sides with haemothorax or pneumothorax) – (450242.5)	2	
			94 (all grades) (30.3%)

Abdomen

One AIS grade 6 (maximum) injury was coded in one case and four grade 5 injuries were coded for the abdomen. There were 37 (11.9%) injuries coded for the abdomen from the study population, see Table 4.9 below.

Table 4.9. Number and type of injury incurred and the AIS code (in brackets) for the abdominal region.

Region: ABDOMEN	Type of injury incurred and AIS code	Number of cases	Total no. of injuries for the population
Grade 6 – maximum	• Liver laceration (hepatic avulsion with total separation of all vascular attachments) – (541830.6)	1	1 grade 6 injury
Grade 5 – critical	• Major abdominal aortic laceration – (520208.5) • Massive laceration of the pancreas – (542832.5) • Massive laceration of the spleen – (544228.5)	2 1 1	4 grade 5 injuries
			37 (all grades) (11.9%)

Spine

Spinal injuries included two cases with an AIS grade 6 (maximum) injury and one AIS grade 5 (critical) injury in one case, see Table 4.10. Eight (2.5 %) spinal injuries were coded in total.

Table 4.10. Number and type of injury incurred and the AIS code (in brackets) for the spinal region.

Region: SPINE	Type of injury incurred and AIS code	Number of cases	Total no. of injuries for the population
Grade 6 – maximum	• Cervical spinal cord (complete cord syndrome with quadriplegia or paraplegia with no sensation) C3 or above with dislocation – (640274.6)	2	2 grade 6 injuries
Grade 5 – critical	• Lumbar spinal cord laceration with fracture and dislocation – (640650.5)	1	1 grade 5 injury
			8 (all grades) (2.5%)

Upper extremity

No AIS grade 5 or 6 injuries were coded. The total number of injuries for the region was 25 (8.0%).

Lower extremity

No AIS grade 5 or 6 injuries were coded and the total for the region was 41 injuries (13.2%).

External, skin and subcutaneous tissues

One AIS grade 6 (maximum) injury was coded for one case, shown in Table 4.11. There were no grade 5 injuries coded. The total number of injuries coded for the region was two (0.6 %).

Table 4.11. Number and type of injury incurred and the AIS code (in brackets) for the external region.

Region: EXTERNAL	**Type of injury incurred and AIS code**	**Number of cases**	**Total no. of injuries for the population**
Grade 6 – maximum	• Second and third degree burns to greater than 90% TBSA – (912032.6)	1	1 grade 6 injury
Grade 5 – critical		0	0 grade 5 injuries
			2 (all grades) (0.6%)

4.6.3 Overall cause of death for the population

Not only did many of the victims receive more than one injury to a particular body region, but many victims were found to have received multiple injuries to multiple body regions. Table 4.12 below describes the injury or injuries that were actually responsible for the death.

Table 4.12. Number of fatalities by injury for the total trauma death population (56 cases).

Cause of death by injury	Number of cases
Multiple injuries	13
Asphyxiation	11
Head injuries	11
Thoracic aortic injuries	8
Cardiac injuries	4
Exsanguination	3
Fractured cervical spine	2
Multi-organ failure and septic shock	2
Pneumonia post chest injury	1
Electrocution	1
Total	**56**

4.6.4 The Injury Severity Score (ISS) and New Injury Severity Score (NISS)

Both the ISS and the NISS provide a measure of the combined effects of multiple injuries and, therefore, the potential for survival. The ISS is a well recognised grading system that has been in use for over 20 years. As described in the literature review (Chapter Two), the ISS is the sum of the squares of the highest AIS grade of injury for three different body regions, the total of which provides the ISS and a guide on the probability of survival. The NISS meanwhile, is the sum of the three highest

AIS grade injuries regardless of body region and is thought to be a more reliable indicator of potential survival. The NISS, designed to address the deficiencies in the older system, was introduced in 1997 as an updated version of the ISS. Due to the familiarity of the ISS and the likelihood of acceptance of the newer grading system, both systems have been included in this discussion.

The range of Injury Severity Scores and NIS scores for the study population was 9 to 75. The number of victims within the various ranges of ISS and NISS are shown in Table 4.13. Two cases that did not undergo an autopsy, and did not have obvious external injuries, were excluded from this summary. Other exclusions from Table 4.13 include the fatality due to electrocution and those persons who were found to have died as a result of hanging (despite the head not being examined as part of the autopsy). For those persons where the head was not examined, existing physiological injuries were not identified nor consequently coded.

The AIS, ISS and New Injury Severity Scores can not be awarded to victims where the actual injury is not identified as previously discussed. Information on the trauma population presented in Table 4.13 is therefore, from a study population of 45 cases. Those cases above ISS and NISS 25 (highlighted) are unlikely to survive, while those in the ranges from 1 – 25 are thought to have a reasonable chance of survival.

Table 4.13. Number of cases within the various ISS and NISS ranges (population of 45 cases).

ISS and NISS range	Number of cases using ISS	Number of cases using NISS
1-9	1	1
10-16	3	0
17-25	7	7
26-34	8	4
35-41	6	5
42-50	2	7
51-75	18	21

The NISS system considers the three highest AIS grades regardless of body region, which results in higher scores than cases scored using the ISS. Table 4.13 shows more victims graded in the higher ranges of 42-50 and 51-75 and, therefore, a decreased likelihood of survival using the NISS than the ISS scoring system. As shown in Table 4.13, 20 cases fell within the 42 – 75 range using ISS, while the NISS system increased the number in the range from 42 – 75 to 28 cases. These injuries are considered to be incompatible with survival.

The benchmark for review of cases when determining the potential preventability of death and appropriateness of care is a score of 25. Those persons with either an ISS or NISS of 25 or less should be fully reviewed in light of the (reduced) severity of the injury comparatively with an ISS/NISS of 50 or 75. Table 4.14 (see p. 74) shows the seven cases from the study where the ISS and in many cases, the NISS also, were 25 or below. The column on relevant co-morbidity and significant factors highlights other important factors that contributed to the fatality, such as environmental factors, age and co-morbidity. Various cases included in the table (marked with an asterisk) were evaluated by the expert panel, the results of which are presented later in the chapter.

Table 4.14. Age, co-morbidity, post mortem cause of death and injuries incurred in cases with an ISS/NISS of less than 25.

Case no.	ISS/ NISS grade	Mechanism of injury	Injuries incurred and AIS code (in brackets)	Age	Relevant co-morbidity & significant factors	Post Mortem 'Cause of Death'
25	9/9	Head injury /Drowning	• Depressed skull #, front right side and across floor of skull – (150404.3)	15	Injury occurred while diving into river	"A result of a fractured skull and drowning"
55*	13/22	Suicide, lacerated wrists and neck	• 7cm neck laceration – (310606.3) • 13.5 cm lacerated right wrist – (710604.2) • wrist tendon damage – (740200.1) • Lacerated external jugular – (320606.3)	25	Psychiatric history. Extended period of time before found	"A result of a cut of the external jugular vein"
22*	16/20	MVA	• # sternum – (450804.2) • # ribs, flail chest – (450260.4)	78	Severe CORD, oesteoarthritis, IHD, elderly	"A result of pneumonia following a chest injury"
48*	16/20	MVA	• Pericardial tear, 4.5cms – (441602.2) • Major laceration to superior vena cava (with blood loss > 20% by volume) – (421806.4)	65	Motor scooter versus power pole	"A result of a ruptured heart"
58	19/27	Homicide, lacerated neck	• Multiple lacerations to anterior neck – (310604.2) • Penetrating laceration to carotid artery – (320408.3) • Laceration to left internal jugular vein – (320806.3)	1	Extended period until found, approximately 24 hours	"A result of exsanguination due to laceration of the left common carotid artery and left internal jugular vein resulting from a penetrating wound to the left neck"

Case no.	ISS/ NISS grade	Mechanism of injury	Injuries incurred and AIS code (in brackets)	Age	Relevant co-morbidity & significant factors	Post Mortem 'Cause of Death'
			• Stab wounds to left upper chest wall – (410602.1) • Mild cerebral oedema with flattened cerebral gyri – (140670.3)			
16*	20/20	MVA	• "punctate haemorrhages of cerebral contusion in the left basal ganglia" – (140642.4) • Kidney contusion NFS – (541610.2)	41	Right kidney tumour, trapped for 1 hour	"A result of inhalation of vomitus following cerebral contusion"
19*	20/24	MVA	• C5-C6 incomplete spinal cord syndrome – (640210.4) • Cervical cord disc herniation, NFS (650200.2) • # right proximal tibia – (853404.2)	68	Chronic IHD, Past M.I., CORD, obese, smoker 20 per day/40 years	"Death resulted from IHD and CORD complicated by acute alveolar damage and cardiac failure"

Key: * = cases evaluated by the expert panel
CORD = Chronic Obstructive Respiratory Disease
IHD = Ichaemic Heart Disease
MI = Myocardial Infarction
# = Fracture
Punctate haemorrhage = Petechial haemorrhage
NFS = Not Further Specified

4.7 Trauma Systems Management (emergency service and intra-hospital transfers)

During the period covered by the data collection for the study, the St. John Ambulance Service – Central Districts followed contractual guidelines for the provision of ambulance services to the public. The guidelines were determined by the Central Regional Health Authority (RHA) in 1994 (Bain, Bradley & Peacock). Stipulated within the guidelines are recommendations for appropriate response times to the various categories of patient calls. Category C calls (calls relevant to the present study) include unplanned calls requested by any person as a result of illness or injury and are further categorised into Category C - Accidents and Category C – Medical. The category of calls is further divided into Priority 1, 2 and 3 (refer to Appendix Twelve). The Central RHA contract with the ambulance service specifies times for the location of urban and rural Category C Accident-Priority 1 calls, (urgent calls requiring immediate dispatch using warning devices for accident victims).

As it is unknown if any of the calls received were requested as Priority 2 calls all calls have, therefore, been recorded as Priority 1. Of the trauma calls received at the Regional Control Centre (RCC), 12 incidents were in an urban setting and 33 incidents were in a rural setting (an ambulance was not called to all incidents). The contract specifies that 80% of all urban incidents are located within 10 minutes from the time of receipt of the call and 95% of incidents are located within 20 minutes from receipt of the call. Incidents occurring within a rural setting are to be located within 16 minutes for 80% of calls and 30 minutes for 95% of calls.

In 25 cases the ambulance was called but the person was found to be in cardiac arrest on arrival of the ambulance. These 25 cases were evaluated by the paramedic and the director of St. John Ambulance Service from the expert panel and reviewed for appropriateness of times for dispatch and location of the ambulance crew to the scene of the incident. The paramedic and the director of St. John Ambulance Service found that the dispatch of the ambulance to one incident was mismanaged. In this instance, the 111 call was made to the police and received at Wellington Central Headquarters, police staff were unfamiliar with the rural location and directed the ambulance to the wrong road causing a delay in the arrival time by approximately 10 minutes.

Of the 12 urban incidents, 10 incidents were located within the 10 minutes stipulated, meeting the contractual requirements with an 83% response rate. Of the 33 rural incidents, 23 incidents were located within 16 minutes (69.6% response rate) and 31 incidents within 30 minutes (93% response rate) which is marginally outside the recommended times stipulated in the contract. Data on these response times is however, only on the study sample of trauma fatalities, it does not include either live trauma victims or those Category A, B or D, Priority 2 and Priority 3 patients. Data on response times and distance from the incident to the medical facility for the 20 trauma death cases evaluated by the expert panel is presented in Tables 4.15. and 4.16.

Data presented in Tables 4.15 and 4.16 is only on those 20 persons who were alive when the emergency service arrived at the scene, and then subsequently died after receiving treatment from personnel in the trauma system. Table 4.15. presents information on those persons who died at the scene of the incident and the one person who died in transit to hospital, while Table 4.16 presents information on those persons who died as hospital in-patients.

Table 4.15. Time and distance between location of incident and medical facility (Palmerston North Emergency Department) for those persons who died at the scene of the incident (not found in cardiac arrest) and the one person who died in transit.

Case no.	Time from receipt of call until located (mins)	Time from location until arrival at hospital (mins)	Total time from call until hospital arrival (mins)	Urban or Rural	Distance from ambulance station to incident* (kms)	Means of transport	Time from incident until death	Notes
55	1 minute	NT	NA	Urban	On-site	T	2 minutes	NCAWF, DAS
48	4 minutes	NT	NA	Urban	2.5	NT	15 minutes	NCAWF, DAS
41	22 minutes	NT	NA	Rural	8	NT	30 minutes	NCAWF, DAS, trapped by legs and feet, length of time unknown
54	19 minutes	NT	NA	Rural	17.5	NT	40 minutes	NCAWF, DAS
16	29 minutes	NT	NA	Rural	36	T	75 minutes	NCAWF, DAS, trapped by legs for 1 hour, Cardiac arrest while trapped
30	4 minutes	88	92	Rural	25	Helicopter	99 minutes	DIT

Key: NT = Not Transported; NA= Not Applicable;
NCAWF = Not in Cardiac Arrest When Found (by ambulance service)
DAS = Died At Scene; DIT = Died In Transit; DIH = Died In Hospital
* Distance from ambulance station or previous location of ambulance to incident. (Distance in this table is half the distance recorded on the ambulance case record slip which states the return mileage for each trip).

Table 4.16. Time and distance between location of incident and medical facility (Palmerston North Emergency Department) for persons who Died In Hospital (DIH).

Case no.	Time from receipt of call until located (mins)	Time from location until arrival at hospital (mins)	Total time from call until hospital arrival (mins)	Time from arrival at 1st hospital until transfer to 2nd hospital (mins)	Urban or Rural	Distance from ambulance station to incident * (kms)	Means of transport	Time from incident until death	Notes
2	8	24	32	N/A	Urban	1	Ambulance	1 hour	DIH, trapped for 20 minutes
21	6	65	71	N/A	Urban	2	Helicopter	24 hours	DIH
4	5	76	81	N/A	Urban	2	Helicopter	2 days	DIH
22	6	22	28	N/A	Urban	3	Ambulance	13 days	DIH
61	9	65	74	5 hours	Urban	18	Helicopter	17 days	DIH
26	18	25	43	N/A	Rural	30	Helicopter	2 hours	DIH
23	13	33	46	N/A	Rural	13.5	Ambulance	3 hours	DIH
44	14	61	75	N/A	Rural	17.5	Helicopter	3 hours	DIH, trapped for 54 minutes, scooped and transported immediately
39	31	80	111	N/A	Rural	24	Helicopter	3 hours	DIH, trapped upside down in car for one hour from time located until extricated (1.5 hours total from time of incident)
36	23	26	49	N/A	Rural	29.5	Ambulance	4 hours	DIH
6	13	72	85	N/A	Rural	16	Ambulance	6 hours	DIH, long on scene time, located at rear of facility, difficulty getting

Case no.	Time from receipt of call until located (mins)	Time from location until arrival at hospital (mins)	Total time from call until hospital arrival (mins)	Time from arrival at 1st hospital until transfer to 2nd hospital (mins)	Urban or Rural	Distance from ambulance station to incident * (kms)	Means of transport	Time from incident until death	Notes
									access to patient and retrieving resuscitation equipment
13	16	40	56	N/A	Rural	12.5	Helicopter	21 hours	DIH
14	11	49	60	N/A	Rural	12.5	Ambulance	24 hours	DIH
19	12	47	59	Within 12 hours	Rural	15.5	Ambulance	3 days	DIH

Key: NT = Not Transported; NA= Not Applicable;
NCAWF = Not in Cardiac Arrest When Found (by ambulance service)
DAS = Died At Scene; DIT = Died In Transit; DIH = Died In Hospital
* Distance from ambulance station or previous location of ambulance to incident. (Distance in this table is half the distance recorded on the ambulance case record slip which states the return mileage for each trip).

A total of 11 victims from the initial trauma death population of 56 persons did not have any involvement with the ambulance service and, therefore, the ambulance component of the trauma management system, as it related to these cases, was unable to be evaluated. The other 25 persons were evaluated by the paramedic and the director of St. John Ambulance Services for the times of dispatch and location of the person post-incident, as discussed earlier in this section.

Of all the incidents attended by ambulance officers, there were seven occasions where the incident was not attended by a paramedic. Of the twenty cases reviewed by the panel, this was found to be a contributing factor in the one death classified as 'potentially preventable' by the expert panel (case number 16). The preventable death occurred in an isolated area of New Zealand and the geography was thought to play a significant part in the injury complex. As part of the panel findings, it was determined that if the incident had been attended by a paramedic, the patient's deteriorating condition may have been recognised sooner and treated accordingly.

4.8 The Relationship Between Severity, Multiplicity of Injury and the Category of Trauma

Trauma deaths for the population were predominantly due to blunt trauma (80.3%) such as road crashes and falls as presented in Table 4.2. In comparison, 17.8% of deaths were due to penetrating injuries, four of which were homicides. Table 4.17 shows the mechanism of injury cross-classified with the cause of death and location of death.

From the data, it appears that those persons who received their injuries as a result of blunt trauma were more likely to have incurred multiple injuries to a number of body regions (ranging from two to seven regions). These injuries were predominantly a ruptured aorta (the most frequent injury); cerebral contusions either with or without a fractured skull; and lacerations of the heart, lung and liver. Ten of the eleven cases where death was due to asphyxiation via blunt trauma were the result of suicide by hanging, the remainder was a penetrating injury.

Table 4.17. Mechanism, cause and location of death for the trauma population (56 persons).

Cause of death	Mechanism: Penetrating injuries	Blunt injuries	Total	Location: DAS	DIT	DIH
Multiple injuries	-	13	**13**	8	-	5
Asphyxiation	1	10	**11**	9	-	2
Head injuries	3	8	**11**	8	-	3
Injury to the thoracic aorta	2	6	**8**	6	1	1
Cardiac injuries	1	3	**4**	4	-	-
Exsanguination	2	1	**3**	3	-	-
Fractured cervical spine	-	2	**2**	2	-	-
Multi-organ failure and septic shock	-	2	**2**	-	-	2
Pneumonia post chest injury	-	1	**1**	-	-	1
Electrocution	1	-	**1**	1	-	-
Total	**10**	**46**	**56**	**41**	**1**	**14**

Key: DAS = Died At Scene; DIT = Died In Transit; DIH = Died In Hospital

Victims who died following a penetrating trauma were predominantly only injured in one body region. The group of ten persons with penetrating injuries all died at the scene of the incident, with one exception. Comparatively, those persons who received a blunt traumatic injury, if they survived the initial insult, had a greater chance of surviving until reaching hospital.

4.9 Findings From the Expert Panel Review

An expert panel comprising a general/vascular surgeon (who is the director of trauma services for the Auckland Region); a neurosurgeon; an intensive care specialist also employed as the director of the St. John Ambulance Service - Central Region (a position attained after the data collection phase of the study was completed); an emergency department medical specialist and a paramedic reviewed twenty cases from the population of trauma deaths for the year from 1 July, 1998 to 30 June, 1999. These 20 cases were chosen for evaluation by the panel as they were deemed to be most sensitive to potential failure within the trauma management system. In all of these cases, the victim was alive when emergency services arrived. Five of the 20 died at the scene of the incident, one person died in transit and 14 deaths occurred in hospital.

The evaluation of the 20 deaths was initially conducted with an independent review by each panel member of the deaths based on case documentation, followed by a group panel meeting. The intensive care specialist and the paramedic were also asked to review the 25 other cases where the ambulance was called and to evaluate the appropriateness of the emergency service response and any potential impact this may have had on the death for these 25 persons. Only four members were able to attend the group panel review session; the evaluation of the fifth panel member was taken into account. The two main objectives of the group panel session were to obtain a classification of death preventability and analyse the appropriateness of care for the 20 trauma victims.

The panel members were asked to consider the pre-hospital management of 20 cases by addressing the following questions:

- Was the length of time between the incident and the arrival of the emergency service personnel relevant in terms of patient survival?

- Were ambulances suitably crewed for the area and the population of trauma casualties?

- Was the most appropriate form of transportation used for trauma victims?

- Were trauma victims transferred to the most appropriate hospital in a timely fashion?

Management of the 14 trauma victims who died in hospital was evaluated using the following questions:

- Did personnel involved in the management of the patient follow the appropriate procedures within the trauma system?

- Did personnel provide adequate clinical care?

- Did the Palmerston North Hospital trauma team follow guidelines satisfactorily and were the guidelines applicable?

- Were there any deficiencies in the trauma management system? If so, what were they?

4.9.1 Results of the panel evaluation

The twenty cases were evaluated using the 'Outcome Questions [to be] Answered for Each Case' (Maio et al., 1996) (see Appendix Eight). Questions asked of the panel included an evaluation of the chance of survival given the patient's injuries and circumstances; determination of the principal cause of death; and classification of the death as either preventable, potentially preventable, not preventable or undecided. Questions that focused on the trauma system included the following: an evaluation of the appropriateness of care and the relevance of treatment received in relation to the death; a recommendation for changes to the trauma system which could have improved the patient's chance of survival, and if there were any recommendations for improvement, what recommendations would the group make.

At the conclusion of the group panel meeting 18 of the 20 deaths were classified as 'not preventable' and one death was classified as 'possibly preventable'. In one case the panel determined that the death could not be classified because there was insufficient information available; the patient had been transferred out of the region, and the patient's notes for the two subsequent hospitals attended were unavailable for review, so that an informed evaluation on the appropriateness of care received could not be made.

There was total panel consensus in 14 of the 20 cases, while in six cases a majority of four members determined the classification of death. The results of the evaluation of the

20 cases with the independent classification of the deaths and the group panel classification are shown in Table 4.18. (see p.86 and 87).

Table 4.18 presents the anticipated outcome of survival for the independent evaluation (on the left) and the for the group evaluation (on the right side of the tables). The chance of survival (a percentage of 100) after consideration of the persons injuries was also estimated by each panel member independently and then the death was classified in terms of preventability. The same process was repeated by the group review.

The independent evaluation of the cases yielded quite different results from those following the group panel meeting presented in Table 4.18. There was limited consensus of opinion in either the anticipated outcome, the chance of survival or the classification of death with the independent evaluations. At the group meeting, however, the neurosurgeon provided a specialist view on the operability and the potential survivability of those persons who suffered a significant insult to the brain, information that often swayed the group decision on the anticipated outcome and the final classification of death. Likewise, the general/vascular surgeon contributed information to the group discussion often providing greater insight on the likelihood of survival and the appropriateness of patient management with major trauma victims of this kind. Given the constraint of the evaluation protocol used, the panel felt that they were unable to provide an estimate of the chance of survival for persons during the group evaluation and, therefore, the chance of survival for the group evaluation was not included in Table 4.18.

Table 4.18. Panel results of the 20 cases reviewed.

Case no.	Independent evaluation: Anticipated outcome	Independent evaluation: Chance of survival	Classification of death	Group evaluation: Anticipated outcome	Group evaluation: Classification of death
54	As expected (5)	0% (3) <25% (2)	NP (4) PP (1)	As expected (5)	NP < 25% (5)
55	As expected (4) Worse (1)	0% (3) <25% (2)	NP (4) PP (1)	As expected (5)	NP < 25% (5)
16	Worse (1) Much worse (3) Insuf. Info (1)	>50% (4) ? (1)	PP (4) ? (1)	Worse (4) Much worse (1)	PP 25-75% (5)
48	As expected (4) Worse (1)	0% (2) <25% (3)	NP (4) PP (1)	As expected (5)	NP < 25% (5)
41	As expected (4) Worse (1)	0% (2) <25% (2) > 50% (1)	NP (3) PP (2)	As expected (4) Worse (1)	NP < 25% (4) PP 25-75% (1)
30	As expected (5)	0% (5)	NP (5)	As expected (5)	NP < 25% (5)
23	As expected (5)	0% (1) <25% (2) <50% (1) >50% (1)	NP (3) PP (2)	As expected (5)	NP (5)
39	As expected (5)	0% (2) <25% (3)	NP (3) PP (1) ? (1)	As expected (5)	NP (4) ? (1)
44	As expected (5)	0% (1) <25% (4)	NP (5)	As expected (5)	NP (5)
26	As expected (5)	0% (3) <25% (2)	NP (4) ? (1)	As expected (5)	NP (5)
21	As expected (5)	0% (3) <25% (2)	NP (5)	As expected (5)	NP (5)
36	As expected (2) Worse (2) Insuf. Info (1)	0% (1) <25% (1) <50% (1) >50% (1) ? (1)	NP (1) PP (2) ? (2)	As expected (4) Worse (1)	NP (4) ? (1)
61	As expected (4) Worse (1)	0% (3) <25% (1) >50% (1)	NP (4) Insuf info (1)	As expected (5)	Insuf. Info to classify death(4) NP (1)
22	As expected (3) Worse (1)	<25% (3) <50% (1)	NP (2)	As expected (4)	NP (4) PP (1)

Case no.	Independent evaluation		Classification of death	Group evaluation	
	Anticipated outcome	Chance of survival		Anticipated outcome	Classification of death
	Insuf. Info (1)	? (1)	PP (2) ? (1)	Worse (1)	
19	As expected (2) Worse (3)	<25% (1) <50% (2) >50% (2)	NP (2) PP (3)	Worse (4) As expected (1)	NP (5)
2	As expected (5)	0% (4) <25% (1)	NP (5)	As expected (5)	NP (5)
6	As expected (5)	0% (3) <25% (1) <50% (1)	NP (3) PP (2)	As expected (5)	NP (5)
13	As expected (5)	0% (4) <25% (1)	NP (5)	As expected (5)	NP (5)
14	As expected (4) Worse (1)	0% (2) <25% (2) <50% (1)	NP (4) PP (1)	As expected (5)	NP (5)
4	As expected (5)	0% (2) <25% (2) ? (1)	NP (3) PP (1) ? (1)	As expected (5)	NP (4) PP (1)

Key: Worse = Worse than expected; Much worse = Much worse than expected;
Insuf. Info = Insufficient information; NP = Not Preventable
PP = Potentially Preventable; ? = Undecided

Note: For the panel member unable to attend the group meeting the classification of death that has been recorded for this member is the same as the panel member's initial independent classification.

Of the 20 cases, six deaths were found to be due to CNS injuries; seven were due to haemorrhage/shock and two deaths were unable to be classified, while four deaths were determined to be due to 'other' causes. The four deaths that were grouped under the heading of 'other' were identified as follows: one case was found to be due to a combination of crushed legs, haemorrhage/shock and poor airway management. The other three cases (classified as other) were each due to anaemia; a pre-existing respiratory condition (CORD) and complications of a spinal cord injury. The principal cause of death for the 20 cases evaluated by the panel is shown in Table 4.19.

Table 4.19. Principal cause of death identified by the panel for the population of 20 cases.

	CNS	Airway	Haemorrhage/ Shock	Other	Indeterminate	Unable to classify
Number of cases	6	0	7	4	2	1

Relevant co-morbidity was determined to be a significant contributing factor in two of the 20 deaths, while age (seventy years plus) was felt to be a contributing factor in three of the deaths. The geographical location of the incident and the time delay resulting from this was also considered to play a significant part in the injury complex particularly for those persons where the incident occurred in a rural setting even when the trauma management system performed satisfactorily.

4.9.2 Problems within the management of the trauma system

The group evaluation provided panel members with an opportunity to comment on the management of trauma systems within the greater Manawatu region and within the context of the deaths being evaluated. The panel was asked to identify deficiencies within the trauma system and state if the deficiencies identified could have contributed to the fatal outcome of the individual. Comments from the panel have been categorised as 'pre-hospital systems problems' and 'hospital systems problems'. Within the category of the hospital system, this has been further divided into 'patient management problems', 'problems with documentation' and 'problems with the post mortem examination'. These issues are presented in the following tables.

Pre-hospital systems problems

Problems identified within the pre-hospital system include a lack of resources, specifically a paramedic in an isolated rural area; inappropriate use of transportation; problems with direct patient care; and, poor documentation of procedures as shown in Table 4.20.

Table 4.20. Pre-hospital systems problems, and the number of their occurrences, identified by the panel for the population of 20 persons.

Problem area	Specific problem	Number
Lack of resources	• Failure to call paramedic to scene	1
Transportation (helicopter)	• Helicopter not activated	1
	• Helicopter dispatch delayed in two cases (for 29 minutes and 31 minutes respectively)	2
	• Helicopter dispatched to wrong job	1
Patient care	• Poor patient assessment (severity of injury under-estimated)	2
	• Trauma cardiac arrest procedure not followed	1
	• Pulse not recorded	1
	• Lack of regular patient observations recorded (pulse, blood pressure, respirations, GCS) resulting in inability to accurately assess decline in patient's condition	1
	• Intravenous access established late	1
	• Insufficient IV fluid resuscitation	1
Airway management	• Patient not intubated	1
	• Patient inappropriately extubated	1
	• Not stated if intubation attempted	1
Lack of documentation	• No mention of spinal immobilisation	3

A paramedic was not called to the scene of the incident in one case evaluated by the expert panel and presented above. This particular incident occurred in a rural area which is not staffed by a paramedic. The closest paramedic to the scene of the incident was located some 100 kilometres away. It would take have taken least 90 minutes for the paramedic to arrive at the scene of the incident by road, and due to the weather conditions at the time, the helicopter was unable to fly. In addition, a GP was already at the scene of the incident which may be a reason for the breach in protocol.

Deficiencies identified within the pre-hospital phase of care, and stated above, include procedures that are recommended for the optimal management of trauma patients. Although the panel identified these deficiencies within the trauma system, they did not consider that the deficiencies contributed to the final outcome.

Hospital systems problems

The panel identified particular problems of patient management within the hospital system. These problems include non-compliance to trauma management protocols; failure to consult with specialists or utilise technology at tertiary referral centres (i.e., consultation with a neurosurgeon for patients with significant head injuries and use of tele-medicine for diagnostics); patient transfers to an inappropriate facility; and, inappropriate management of ventilation for patients with head injuries. This information is presented in Table 4.21. (see p.91).

Although the panel identified a number of deficiencies within the hospital phase of care for those persons who survived admission into hospital, many of the problems were not regarded as deficiencies of the trauma system but differences in the management of patients by individual clinicians. For example, the trauma management protocol does not include guidelines on the administration of blood products to trauma victims, yet all panel members commented that in case number 23, they would have administered blood to the trauma victim. A complicating factor in the management of this patient, is that medical staff were made aware soon after the patient's admission to the emergency department, that the patient was a Jehovah's Witness. Due to the severity and multiplicity of injuries, this knowledge may have been an influencing factor in the decision not to administer blood products.

Table 4.21. In-hospital patient management problems, and the number of their occurrences, identified by the panel for the total population of 20 persons.

Problem area	Specific problem	Number
Trauma management protocol	• Failure to administer blood transfusion prior to surgery • Patient had CT scan (head, chest and abdomen) prior to surgery when haemodynamically unstable (contrary to PNth hospital trauma protocol) • Patient had laparotomy instead of Diagnostic Peritoneal Lavage (DPL) when unstable (contrary to PNth hospital trauma protocol)	1 1 1
Diagnosis	• Neurosurgeon not consulted for management of severe head injury	2
Patient transfer	• Patient transferred to inappropriate hospital (three hospitals in total)	2
ICU management	• Patient not seen by ICU consultant (or failure to document consultation) • Inappropriate patient management within confines of Brain Death Assessment (patient hypothermic - temperature initially 34.3 degrees Celcius; elevated serum sodium level of 156 – normal level is 136-144)	1 2
Ventilatory management	• Patient hypoventilated (elevated CO2 level inappropriate with head injured patient)	2
Failure in mental health system	• Committed patient successful in suicide attempt • First episode of depression, patient inappropriately assessed by mental health workers two days prior to suicide	1 1

Key: PNth hospital = Palmerston North hospital

Additionally, the diagnostic procedure of performing a Diagnostic Peritoneal Lavage (DPL) prior to surgery is also at the discretion of the attending intensivist despite this procedure being recognised as the appropriate diagnostic tool for persons with suspected internal injuries. The DPL is recommended in the Palmerston North Hospital EMT (2000) trauma guidelines as appropriate patient management for persons with suspected abdominal injuries. Again, the panel found that these deviations from recommended protocols, did not affect patient outcome.

Problems with documentation

Table 4.22 and Table 4.23 present information on the lack of documentation in general and also in the recording of information from the autopsy examination. These problems were identified by the panel, but did not prevent the panel from classifying the deaths in terms of preventability. The problems identified in these tables were more of a hinderance for the purposes of reviewing and evaluating patient management.

Table 4.22. Problems with documentation.

Problem area	Specific problem	Number of occurrences
Patient's Notes	• Emergency department notes unavailable	3
Patient's x-rays	• Emergency department x-rays unavailable	2
Incomplete documentation	• Emergency department notes incomplete	2
	• Record of inter-department transfer incomplete	1
	• Record of intra-hospital transfer incomplete	2
	• ICU flow chart unavailable	1

Table 4.23. Problems with the autopsy examination identified by the panel for population of 20 persons.

Problem area	Specific problem	Number of occurrences
Insufficient detail provided	• Volume of blood in abdominal cavity not stated	1
	• Degree of cerebral swelling not stated	2
	• Herniation of brain not stated	3
	• No comment on spinal/vertebral findings	3
Information presented inconsistent with clinical findings	• Fractured pelvis not mentioned	1
	• No mention of leg injury	1
	• Liver laceration stated on post mortem not found at laparotomy	1
	• No mention of dissected aortic aneurysm seen on CT scan	1
	• Post mortem report inconsistent with clinical findings	1
	• Overall quality of post mortem report found to be unsatisfactory	1

4.9.3 Overview of the panel evaluation

While difficulties were apparent, the panel did not find that the deficiencies identified within the trauma management system contributed directly to any of the 20 deaths evaluated. The deaths were evaluated in terms of survivability following an analysis of the entire incident scenario. The incident scenario involved aspects such as the geographic location of the incident; complicating factors such as bad weather (including evacuation by air); motor vehicle incidents involving multiple vehicles and multiple fatalities; ability to extricate victims; the availability of resources at the time; the length of time before medical assistance and patient access was available; and, injuries sustained by the individual.

4.10 Summary of Trauma Deaths in the Greater Manawatu Region

In summary, a relatively young population of deaths from trauma in a one-year period is described. The population is mainly Caucasian, predominantly male, and the single largest category was road crash deaths (blunt trauma) followed by suicides and homicides. Injury to more than one body region was frequent, with the single largest number of deaths attributable to multiple trauma.

One of the objectives of the study was to identify whether improved trauma management systems could reduce the number of preventable trauma deaths, however, 73 percent of deaths occurred before or soon after the arrival of the emergency service at the scene of the incident.

The expert panel of specialists evaluated 20 cases where the victim survived long enough to receive some treatment from medical personnel. The panel's evaluation of the victims showed quite different results when done on an independent basis and a group basis. After discussion, a group consensus on the classification of death was easily reached. There was total panel consensus in 14 of the 20 cases, while in six cases a majority of four members determined the classification of death. At the group meeting, the panel classified 18 of the 20 deaths as 'not preventable'; and one death as 'possibly preventable' (this case will be discussed further in Chapter Five). One case was 'unable to be classified' due to insufficient information. The panel found a number of deficiencies within the trauma system, but it was felt that these deficiencies did not contribute directly to any of the 20 deaths evaluated by the panel.

CHAPTER FIVE: DISCUSSION

5.1 Introduction

Research on trauma deaths, as reported in the literature, has been conducted predominantly in the United States of America and Britain, with most studies focusing on urban populations. Only one study has been conducted in New Zealand; that study, now dated, was located in Auckland (Smeeton et al., 1987), a predominantly urban area. Although the present study conformed as closely as possible to the methodology used in the Auckland study, changes in technology in the past 15 years together with the differences between the urban and rural setting, limit comparability, even with the single other New Zealand study.

This chapter begins with a discussion on the trauma death population demographics, pre-incident data, and the type of incidents encountered in the present study. Where possible, a comparison between findings of the present study and findings from national and international studies is made. Information on the geographical location of incidents and the relevance of the geography is then presented. Discussion then focuses on compliance with available protocols used in trauma management systems in the study region. The one 'possibly preventable death' is analysed as the most sensitive indicator of adequacy of trauma management systems. Methodological issues are then discussed. Finally, the working document *Roadside to Bedside* (Ministry of Health, 1999) and the development of a national trauma service for all New Zealanders is reviewed.

5.2 Demographic Characteristics of the Trauma Death Population

The potential population served by emergency services and trauma services in the greater Manawatu region (incorporating the Horowhenua, Kapiti Coast, Manawatu, Rangitikei and Tararua districts as well as Palmerston North City and the Waiouru ward) was 177,618 persons (based on the 1996 census). Approximately 83% of the population are of European origin, 13% Maori, and four percent are people from the Pacific Islands and other, non-European ethnic groups. The trauma death population distribution for the present study was 71.4% European, 25% Maori and 3.5% classified as other, which shows a disproportionate representation of Maori among trauma deaths during the year of study.

The population of persons under the age of 45 years in the Manawatu region is 69% (Read, 1998). The population of 56 trauma deaths in the present study had an average age of 36.0 years, with 41 persons (73.2%) under the age of 45 years: 34 (60.7%) of these were male and 22 (39.2%) were female.

The leading cause of death for the 15 - 24 age group for both sexes (higher for males) in the Manawatu region is intentional injury followed by motor vehicle crashes (Read, 1998). There were 11 males (19.6%) and six females (10.7%) in the 15 – 24 age group from the trauma death population in the present study who died. The leading cause of death for both males and females was motor vehicle incidents followed by suicides (intentional deaths). Homicidal deaths accounted for two of the 11 male deaths. Unlike the author of the present study, however, Read does not make the distinction between traumatic and non-traumatic deaths.

A rural Australian study by the authors Papadimitriou, Mather and Hill (1994), with a similar rural/urban population distribution to the present study had a population spread of 76% male and 24% female. *A study of preventable trauma mortality in rural Michigan* presented a similar distribution of male and females to the Australian study, with 71.6% and 28.4% respectively (Maio et al., 1996). Additionally, a study on preventable trauma deaths in rural Montana by Esposito et al. (1995) also showed a gender distribution of 74% male and 26% female. Again, the Auckland study (Smeeton et al., 1987) had a significantly higher number of deaths in the 15 - 24 age bracket with twice as many male as female deaths. This predominantly younger (15 - 24) age and male gender distribution for trauma deaths is also identified by Trunkey (1983) in one of the earlier papers presented on trauma. The present study of trauma deaths in the Manawatu region shows a similar profile to trauma deaths elsewhere: more males (60.7%) than females (39.2%), with a disproportionate representation of the 15 – 24 year age bracket (30.3%).

5.2.1 Cause of fatal injury

The mechanism of injury for over half of the trauma death population in the present study was road crashes (31 persons, 55.3% of deaths). Suicide accounted for 16 deaths (28.5%), with 10 deaths (17.8%) as a result of hanging and four due to gunshot wounds (7.1%); one death was that of a pedestrian who jumped into the path of an oncoming truck and trailer unit, and one person who slashed a wrist and neck. Homicidal deaths accounted for five deaths: three due to stabbing or slashing; one accidental shooting; and, one hit and run victim who was a bicyclist. Other causes of death included a fall, an electrocution, one burns victim, and one drowning following a head injury, (refer to Appendix Nine - map of fatalities).

Read (1998) found that unintentional injury accounted for 41% of deaths in the 5 - 14 year age group and unintentional injury followed by motor vehicle crashes were the leading causes of death for both sexes in the 15 - 24 and the 25 - 44 year age groups. From 45 years onward, Read identified the leading causes of death as diseases of the circulatory system, followed by cancer and Ischaemic Heart Disease (IHD). Because this study involved a census of all trauma deaths within the region comparisons cannot be readily made with studies conducted elsewhere. In all of these latter studies only a subset of trauma deaths were examined, for example, road deaths, or the exclusion of suicides.

5.2.2 Blunt versus penetrating trauma

Some authors (e.g., Esposito et al., 1995) differentiate between unintentional and intentional deaths. These distinctions were not used in the present study as some of the deaths may not be classified correctly. Although most suicides may be intentional some apparent suicides may in fact be accidental (e.g., incidents involving a firearm). Likewise, not all homicides can be considered intentional such as a 'hit and run' incident, while an incident involving a motor vehicle, particularly car versus train incidents, can arouse some degree of suspicion. More importantly, whether or not a death is intentional *does not* affect the provision of emergency services and subsequent trauma management. The distinction used in the present study was instead made between blunt and penetrating injuries. The difference between blunt and penetrating injuries is significant in terms of patient management and investigation of the injuries in particular. Blunt injuries, such as motor vehicle incidents and falls, often involve more than one body system and not all injuries may initially be obvious. In comparison, penetrating injuries are generally more obvious and regionally specific.

In the present study blunt trauma (motor vehicle incidents, falls, pedestrians struck and hangings) accounted for 45 deaths (80.3%), while penetrating wounds (gunshot or stabbing) accounted for ten deaths (17.8%) and one death was the result of extensive burns (1.7%). Smeeton et al. (1987) stated that blunt trauma accounted for 88.5% of deaths in their study, penetrating wounds for 6.5% and burns 5.0% of deaths. Champion et al. (1990) evaluated 80,544 trauma patients (both alive and dead) and concluded that the ratio of blunt-injured to penetrating-injured patients was nearly 4:1. Similarly, a ratio of 4:1 blunt to penetrating *deaths* was found in the present study. Champion et al. excluded all cases where the death occurred either at the scene of the incident or in-transit to hospital, information that was included in the present study. The results were the same despite the different subsets of trauma victims in the two studies. Comparisons with other studies that include all trauma deaths show that the proportion of penetrating to blunt injury deaths is consistent at this ratio of 4:1.

Sampalis et al. (1993) identified that injuries to particular body regions were associated with a definitive outcome. For example, injuries to the head, either isolated or in combination with injuries to other regions, as well as injuries to the chest and abdomen were associated with increased odds of dying, as were injuries to more than one body region. Stothert et al. (1990) also identified an increase in the number of class 1 errors (errors with a probable negative impact on prolonging survival) in the blunt trauma group compared with either penetrating injury or burns. The difference appears to be a combination of factors related to the nature of blunt injury involving more than one body region or organ system. Multiple trauma, the authors say, is compounded by orthopaedic, neurosurgical and other sub-specialty areas of concern, hence the potential for errors and missed diagnoses is compounded (p. 1024).

Danne et al. (1998) also found a significantly higher number of preventable deaths and potentially preventable deaths in patients whose injuries had been due to blunt trauma;

in patients with head injuries with a low GCS; in older patients, and in patients undergoing inter-hospital transfer. Danne et al. state that more complex multi-system trauma lends itself to more complex management processes and therefore greater room for error. In addition, those groups of patients who have the potential for greater physiological disturbance from their injury (older patients, and head injured patients – through 'secondary brain injury' processes) have greater room for management error. These groups of patients are more likely to be included in the inter-hospital transfer process, leading to a potential for higher 'preventable' or 'possibly preventable' death outcomes in this group (Danne et al., 1998).

The sample size of 20 trauma deaths clinically evaluated in the present study limits the confidence in making a comparison of results for blunt versus penetrating trauma and subsequent preventability of death. However, the one death classified as 'possibly preventable' from the population of deaths evaluated by the panel was a result of blunt trauma, and the injuries incurred were a combination of a crush injury requiring extrication from the vehicle following an extended period of time, accompanied by a head injury. This injury scenario was further complicated by the fact that the incident occurred in an isolated rural area which would have made the management of this patient difficult and open to errors.

5.3 Contributing Pre-incident Factors

Data from other studies will be discussed in relation to the present study on pre-incident factors that contributed to the deaths due to trauma. These factors include positive blood alcohol levels, speed in motor vehicle related deaths, safety practices and co-morbidities.

5.3.1 Positive blood alcohol levels, speed and safety practices

Positive blood alcohol levels were found in a total of nine trauma victims from the population of 56 persons (22 cases had no blood alcohol assay done). Blood alcohol levels were determined on all of those victims involved in motor vehicle incidents, but not on all persons included in the study. ESR blood alcohol assays taken on the 33 motor vehicle related deaths showed that eight (24.2%) of the road crash deaths were influenced by alcohol. Table 4.3 (in Chapter Four) shows that of these eight cases, only one blood alcohol level was below the legal limit of 80 milligrams of alcohol per 100 millilitres of blood.

Inappropriate high speed was also a contributing factor to the death in each of the eight alcohol-positive motor vehicle related deaths. In two cases speed was excessive: 150 kilometres per hour in a 50 kilometre per hour zone and 155 kilometres per hour in a temporary 30 kilometre per hour zone. In all but one of the eight cases there was failure to use safety equipment such as seat-belts and helmets in addition to behaviour that was potentially hazardous such as crossing the centre line on the road. Six of the eight cases died at the scene of the incident, with the other two deaths both occurring within three hours post-incident. The cause of death for these eight victims were multiple injuries (five cases), and in one case each injuries to the thoracic aorta, the heart and the head. The rapidity of death for these victims reflects Trunkey's (1983) theory on the trimodal distribution of trauma deaths with the first peak occurring almost immediately from injury to the brain, heart and great vessels.

There were few studies reviewed where blood alcohol levels and the relevance of speed and safety practices were recorded. The three studies where some comparison of results were possible are those by Papadopoulous et al. (1996), Esposito et al. (1995) and Smeeton et al. (1987). The study by Papadopoulous et al., however, was conducted in an urban region and included only those trauma victims who were dead on arrival (DOA) at the hospital. Blood alcohol levels were available on 57 of the 82 DOAs with 10 persons testing positive for blood alcohol. Papadopoulous et al. concluded that even when the blood alcohol level was within the legal limits (less than 100 milligrams per decilitre), injuries suffered by those in the alcohol-positive group were more severe than those in the alcohol negative group (although these injuries were not described).

Esposito et al. (1995) detected alcohol present in 49% of rural motor vehicle related cases and 43% of those victims had a blood alcohol level greater or equal to the legal definition for intoxication (level not stated). These authors also provide statistics on the use of restraints in their study population, stating that 83% of vehicle occupants were unrestrained. However, the authors do not state if there was a correlation between the victims with a positive blood alcohol level and those who were unrestrained, nor do they comment on the legal requirement for the use of seat-belts or the significance of their findings.

The Auckland study by Smeeton et al. (1987) encompassed a predominantly urban population where road crash fatalities accounted for 70% of the trauma deaths. Smeeton et al. found a blood alcohol level over the legal limit (80 milligrams per 100 millilitres of blood) in 37% of drivers, 50% of pedestrians, 25% of passengers and one cyclist. Smeeton et al., like the authors above, do not include data on the extent or type of injuries incurred by the victims of motor vehicle related deaths in their study.

5.3.2 Co-morbidity

The Major Trauma Outcome Study (MTOS) data of the American College of Surgeons obtained from American and Canadian hospitals on 80,544 trauma patients, was used to assess the influence of age on survival in major trauma patients (Champion et al., 1990). The mortality rate of the elderly group (aged 65 years or more), compared with a similarly injured group of patients, was found to be twice that of the younger group (under 65 years). The mortality rate increased sharply between age 45 years and 55 years and doubled by age 75 years. The age-dependent survival decrement occurred for all ISS values, for all mechanisms of injury and for all body regions. In addition, the authors found that the elderly had a markedly higher complication rate particularly from pulmonary and infectious complications (Champion et al., 1990).

The expert panel for the present study similarly found that co-morbidity was a significant contributing factor in two of the 20 deaths evaluated by the panel. In addition, age compounded the effect of pre-existing medical conditions in both of these deaths. Age alone was also considered to be a relevant factor in the deaths of two other persons over 80 years.

5.3.3 Location of death and duration of survival

As shown in Figure 4.3, 41 victims (73.2%) in the present study died at the scene of the incident. Of these, 36 cases (64%) were found to be 'in cardiac arrest' on arrival of the ambulance service while 5 cases (8.9%) were still alive ('not in cardiac arrest'), although died later at the scene. Only one case died in transit to hospital while 14 cases (25%) died in hospital.

Figure 4.4 shows the duration of survival for victims after the initial insult. From the population of 56 trauma deaths, 28 persons (50%) survived for less than ten minutes; a further 12 (21.4%) survived for less than the first hour; another seven (12.5%) survived from 1 to 4 hours; three (5.3%) survived between 4 and 24 hours; 4 persons (7.1%) survived between 1 to 7 days and 2 persons (3.5%) survived between 7 and 17 days.

Table 4.17 (in Chapter Four) shows the cross classification of the type of injury (blunt versus penetrating trauma), the cause of death and the location of death for the total trauma death population. The main causes of death were multiple injuries; asphyxiation; head injuries; injuries to the thoracic aorta; and, cardiac injuries. The ratio of deaths due to blunt injuries to penetrating injuries was 4:1. Deaths due to multiple injuries all followed blunt trauma (motor vehicle incidents and falls). Of these deaths, eight occurred at the scene of the incident and five occurred in hospital. Those persons with multiple injuries who survived long enough to reach hospital tended to have less severe injuries, to have sustained their injuries closer to the hospital, and to have been treated by emergency service personnel sooner than those who died at the scene of the incident.

Death due to asphyxiation was the result of suicide by hanging in ten cases and a homicidal stabbing in one case. Two persons died from asphyxiation as hospital in-patients after attempted suicide by hanging. These two persons were both found soon after the suicide attempt and were still alive (not in cardiac arrest) when found. Deaths due to injury to the thoracic aorta predominantly occurred at the scene of the incident, however, in the case where death occurred in transit and the one case where the death occurred in hospital, this was a direct reflection on the geography, the close proximity of the ambulance service as well as the location of the hospital. Deaths due to a fractured cervical spine both occurred at the scene of the incident. The two deaths due to multi-organ failure and septic shock occurred following the initial insult a number of days post-incident, as did the one death due to pneumonia.

Table 5.1 (see p.104) shows the relationship between the mechanism of death, the cause of death, the location of death, the time from the incident until death occurred and other relevant factors. Included in the table is the expert panel's classification of death preventability. The table is arranged according to location of incident (urban/rural), followed by the length of time from the incident until death (shortest to longest survival time). Urban incidents are followed by rural incidents in the tables again, from shortest to longest survival time.

The data presented in Table 5.1, particularly the 'cause of death' and the 'time from injury until death,' reflect Trunkey's (1983) concept of the trimodal distribution of deaths. Trunkey identifies three peaks of when death after the incident is most likely to occur. The first peak is characterised as 'immediate deaths' (deaths that occur very soon after injury), the second as 'early deaths' (deaths within the first few hours) and third as 'late deaths' (deaths days or weeks after the injury). Trunkey states that over half of all deaths due to trauma are immediate deaths owing to overwhelming injury to the brain, heart, or great vessels and in these cases death is inevitable and unavoidable. The second peak, the early deaths, occur in about a third of cases and these deaths are principally due to brain injuries and haemorrhage. The author emphasises that in patients who die of potentially treatable head injuries the usual cause of death is airway obstruction or aspiration causing acute hypoxia.

Table 5.1. Cross classification of relevant factors on the deaths of the 20 cases reviewed by the panel.

Case no. and cause of death	Cause of death (as per autopsy findings)	Location of death, urban/ Rural	Time from incident to death	Relevant factors such as co-morbidity and scene information	Expert Panel's group classification (majority decision)
(55) Suicide penetrating	Exsanguination	DAS Urban	2 mins	Not found immediately	Not preventable
(48) MBA	Cardiac injury (AIS grade 4)	DAS Urban	15 mins		Not preventable
(41) MVA	Exsanguination	DAS Rural	30 mins	Trapped by legs and feet length of time unknown	Not preventable
(54) MVA Pedestrian	Multiple injuries	DAS Rural	40 mins		Not preventable
(16) MVA	Inhalation of vomitus following cerebral contusions (AIS grade 4)	DAS Rural	95 mins	Trapped by legs for one hour	Possibly preventable
(30) MVA	Injury to thoracic aorta	DIT Rural	99 mins		Not preventable
(2) MVA	Injury to thoracic aorta	DIH Urban	60 mins	Trapped for 20 minutes	Not preventable
(21) MVA	Head injury	DIH Urban	24 hours		Not preventable
(4) Suicide hanging	Asphyxiation	DIH Urban	2 days		Not preventable
(22) MVA	Pneumonia	DIH Urban	13 days	Severe CORD, oesteo-arthritis, IHD, elderly	Not preventable
(61) MVA	Multi-organ failure and septic shock	DIH Urban	17 days		Insufficient information to classify
(26) MVA	Multiple injuries	DIH Rural	2 hours		Not preventable
(23) MVA	Multiple injuries	DIH Rural	3 hours		Not preventable
(39) MVA	Multiple	DIH	3 hours	Trapped for	Not

Case no. and cause of death	Cause of death (as per autopsy findings)	Location of death, urban/ Rural	Time from incident to death	Relevant factors such as co-morbidity and scene information	Expert Panel's group classification (majority decision)
	injuries	Rural		90 minutes	preventable
(44) MVA	Multiple injuries	DIH Rural	3 hours	Trapped for 54 minutes, scooped and transported immediately (multi-car crash)	Not preventable
(36) MVA	Multiple injuries	DIH Rural	4 hours		Not preventable
(6) Suicide (hanging)	Asphyxiation	DIH Rural	6 hours	Long on scene time, difficulty accessing patient	Not preventable
(13) Suicide (gunshot)	Head injury	DIH Rural	21 hours		Not preventable
(14) MVA	Head injury	DIH Rural	24 hours		Not preventable
(19) MVA	Multi-organ failure and septic shock	DIH Rural	3 days	Chronic IHD, past MI, CORD, obese, smoker	Not preventable

Key: DAS = Died At Scene; DIT = Died In Transit; DIH = Died In Hospital;
MVA= Motor Vehicle Accident; MBA = Motorbike Accident;
IHD = Ischaemic Heart Disease; MI = Myocardial Infarction;
CORD = Chronic Obstructive Respiratory Disease

Comments made by the expert panel when reviewing the 20 cases from the present study for the appropriateness of trauma management, included the necessity to consider the location of the incident as an integral part of the injury complex. Within the study population of 56 persons, 42 incidents (75%) occurred in a rural setting and 14 (25%) occurred in a built-up area (see Appendix Nine – map of fatalities). From the population of 20 deaths evaluated by the panel, six persons were known to have been unattended or inaccessible for periods ranging from 20 minutes to 90 minutes post-incident. Reasons for this were either because they were not found sooner, because of entrapment in a vehicle, or as a result of triaging. Again, the importance of the geography and extenuating circumstances such as entrapment must be considered within the context of the entire injury complex and "the golden hour". Esposito et al. (1995) suggest that time and distance factors may serve as a natural triage system in which those persons with non-survivable injuries often die before receiving medical attention. The results from the present study support Esposito's observation and may, in part, explain the disproportionate incidence of rural fatalities on New Zealand's roads.

5.4 Management of the One 'Possibly Preventable Death'

The expert panel evaluated 20 cases where trauma victims were treated by emergency service personnel through various stages of the trauma system, the results of which were presented in Chapter Four. Eighteen of these cases were classified as 'not preventable', one case was unable to be classified due to insufficient information (case number 61), and one case was classified as 'possibly preventable' (case number 16). The 'possibly preventable' death is now discussed further.

The expert panel determined that there were a number of issues within the trauma system that may have impacted on the fatal outcome of case number 16. Case number 16 involved a person who rolled a vehicle in a remote rural setting. The length of time between the occurrence of the incident and the location of the victim by St. John Ambulance personnel was 29 minutes. The victim, who was alive and orientated when found, was trapped by the legs and remained so for approximately one hour post arrival of the ambulance. Once released from the vehicle, the victim suffered a cardiac arrest and despite Cardio-Pulmonary Resuscitation (CPR) by ambulance personnel the person died. The victim had recently stopped for a meal prior to the incident. The delivery of CPR with closed chest compressions by emergency service personnel without airway protection, is likely to have resulted in the aspiration of vomitus. The time from the incident until death was 95 minutes. The autopsy cause of death was stated as "death due to the inhalation of vomitus following cerebral contusion."

The medical management of the victim by ambulance officers and a local General Practitioner (GP) at the scene appeared to be limited due to poor accessibility to the trapped patient by personnel. The expert panel identified and commented on deficiencies in the pre-hospital management of case number 16 and identified various breaches of protocol.

Deficiencies in the pre-hospital phase of care in this case included insufficient recording of patient observations (pulse, respirations, blood pressure, GCS and pain score) taken by the ambulance officer. This limited information made it difficult for panel members to assess if the treatment administered was deficient (only two sets of observations were recorded on the Ambulance Patient Report within a period of 50 minutes). The victim was attended to by three ambulance personnel and the GP. However, the protocol states that a paramedic (ACO) should have been called to attend the incident. This did not occur. As stated in Chapter Four, this incident occurred in a region where ambulance station staff do not include a paramedic. The nearest paramedic is 90 minutes away by road, and unfortunately, the helicopter was unable to fly due to inclement weather. The presence of the GP appears to have further influenced the decision not to call for paramedic assistance. Although intravenous fluids were administered to the patient, as per the protocol for treatment of shocked persons, the volume of fluids given were thought to have been insufficient in view of the patient's injuries. The panel found that the timely intervention by a paramedic may have prevented the death.

The release of the patient from the vehicle was thought to have had an impact on the death with progressive shock likely to have occurred once the compression was released. The panel concluded that this death was 'possibly preventable' and the presence of a paramedic, as required in the St. John Ambulance Service procedure manual, could have assisted with earlier detection of the patient's deteriorating level of consciousness and haemodynamic decline prior to the cardiac arrest.

The panel found the autopsy report to be of inferior quality for two reasons. There was no mention of a suspected fractured pelvis which was considered to be highly likely following the pathologist's mention of '...considerable haemorrhage in the tissues about the bladder'. Nor, did the pathologist mention any leg fractures or obvious injuries to the legs other than superficial abrasions below both knees and the right thigh. The possibility of fractures or significant lacerations to either one or both legs following entrapment by the lower limbs, significant enough to have compromised the circulating blood volume, is thought to have been highly likely and worthy of mention.

Trunkey states that in patients who die from potentially treatable head injuries the usual cause of death is airway obstruction or aspiration causing acute hypoxia. The classification of the death by the panel of case number 16 as 'possibly preventable' reflects Trunkey's (1983) theory: As discussed in the previous section, the cause of death and the time from injury until death reflects Trunkey's theory on the distribution of trauma deaths. The 'cause of death' according to the pathologist was "inhalation of vomitus following cerebral contusion". The cerebral contusion was coded as AIS grade 4, severe, but survivable. As stated earlier in this section, the recent ingestion of food, and the subsequent delivery of closed chest compressions with CPR, was the most likely cause of aspiration (inhalation of vomitus), which should also have been mentioned by the pathologist.

McDermott (1994), and Stocchetti et al. (1994) both commented that the most frequent error occurring with preventable deaths was inadequate fluid resuscitation. This error was often exacerbated by poor perception of the severity of the injury or a deterioration in the patient's condition. Esposito et al. (1995), meanwhile, suggest that the time to definitive care may not be as important as the type of care rendered during the pre-hospital phase. These authors suggest that the rate of adverse outcome may be more a function of organisation and education rather than the geographic location of the incident.

5.5 An Evaluation of the Trauma Management System

Issues regarding the trauma management system arising from the present study include compliance with trauma protocols by personnel involved in the management of trauma patients, factors relating to documentation, and implications for the study methodology and its application.

5.5.1 Overall compliance with trauma protocols for the Manawatu study

The expert panel evaluated the compliance of treating personnel to trauma protocols written by the Ambulance Education Council and presented in the 'Patient Care Procedures and Notes' for both Paramedics and Non-paramedics for the St. John Ambulance Service – Central Districts. Regional trauma management guidelines for Palmerston North Hospital (EMT, 2000) and national guidelines on trauma management (Royal Australasian College of Surgeons, May 1994) were also used to evaluate the treatment provided to trauma patients in the Manawatu region. These findings were presented in Chapter Four and will now be discussed further with respect to these protocols.

The St. John Ambulance Service

The contract that the St. John Ambulance Service has with the Regional Health Authority (Bain et al., 1994) stipulates that 80% of traumatic incidents occurring in urban areas per month should be located within 10 minutes from notification of the incident. This requirement was satisfied in 83% of cases during the year of the present study. For rural incidents, the response rate was 69.9% for the location of incidents within 16 minutes (the requirement being 80% per month) while 93% of incidents were located within 30 minutes (the requirement being 95% per month within 30 minutes). However, the present study represents only a sample of the service provider's activities and may or may not be indicative of actual monthly performance. The study does serve to raise issues over the soundness of such contractual performance measures. Alternative performance levels may be better specified in terms of preventable deaths. No trauma deaths occurred in the greater Manawatu region during the year of study due to inappropriate response times by St John Ambulance Service personnel.

The location of rural trauma victims may have been adversely affected by personnel in the St. John Ambulance Service who failed to comply with the helicopter activation protocol in a number of incidents. The expert panel identified three incidents where the helicopter was not activated in accordance with contractual requirements. In one incident the helicopter was not activated at all when required (contrary to the protocol), and in a further two incidents there was an unexplained delay in the dispatch of the helicopter for a period of 29 minutes and a period of 31 minutes respectively (St. John Ambulance Central District Quality System Procedure, RCC 123, 2000). While, it is unknown if there were other factors which influenced these breaches of protocol, this is unlikely. All Regional Control Centre (RCC) information for each case and the text concerning each incident was reviewed. The RCC daily printout provides a record of all conversations including any circumstances that may affect the incident at hand. For each case in question there were no written comments regarding difficulties that should have affected patient retrieval. The expert panel determined however, that the survival of patients was not compromised as a result of the delay in transportation with any of these cases.

Ambulance patient reports

Ambulance patient reports were available for 35 (77.7%) of the 45 cases where the ambulance service was notified of the incident. The omission of Ambulance Patient Reports occurred despite a protocol stating that a report must be completed on "any patient who is status 0 (deceased) regardless of whether or not the patient is transported" (St. John Ambulance Service Central District Quality System Procedure, DPM 106, 2000). The absence of the Ambulance Patient Report in these incidents meant that the evaluation of the case by the expert panel was reduced to that of the appropriateness of appliance (ambulance and/or helicopter) dispatch times, and not an evaluation of patient care.

Coronial information

The Coroner is required by the Coroner's Act (1988) to conduct an inquest into every death that appears to have been without known cause, a suicide, an unnatural or a violent death. However, it appears to be at the Coroner's discretion whether or not an inquest into a traumatic death is held. In the present study 54 autopsies were performed and inquests held on the population of 56 persons. The two cases where an autopsy was not conducted involved one incident where the victim's motor vehicle was hit by a train, and a second incident which was determined to be suicide by a gunshot wound to the head. The establishment of a non-suspicious death could not categorically be stated in either case. The lack of adherence to the legal requirement of performing autopsies on selected persons suggests that any information collected for the purpose of audits and the detection of trends (such as the increasing rate of suicides) will, therefore, be inaccurate and inconclusive.

Palmerston North Hospital Early Management of Trauma (EMT) guidelines

There were a number of instances where recommended procedures stipulated in the Palmerston North Hospital EMT (2000) guidelines for the management of trauma patients were not adhered too. These instances include the failure to administer a blood transfusion prior to surgery; performing a CT scan on a haemodynamically unstable patient; and, performing a laparotomy instead of a Diagnostic Peritoneal Lavage (DPL) on a haemodynamically unstable patient. Other issues within the hospital setting included in the EMT guidelines, where recommended 'best practice' was not observed, include the failure to consult a neurosurgeon at a tertiary hospital for the management of patients with severe head injuries; failure to adhere to ventilation protocols for head injured patients; and, failure within the mental health system to adequately assess suicidal persons.

In many of the instances mentioned above, it appears that there were other factors that were not documented which may have influenced the clinical management. One example already given in Chapter Four, is regarding the omission of a blood transfusion. In this case medical staff were informed soon after the patient's arrival in the emergency department that the patient was of the Jehovah's Witness faith. The patient had suffered multiple injuries (ISS / NISS of 57) and, irrespective of blood transfusion survival, was unlikely. It may be that the awareness of the patient's religious belief was considered when a blood transfusion was required but not administered.

Despite a 'lack of compliance' with these recommendations and protocols for trauma management, it must be recognised that individual clinical judgement and the time dynamics of emergency situations will affect decisions made by clinicians on patient management. The expert panel identified the issues mentioned above with the benefit of hindsight, an autopsy report, and without the pressure of on-the-spot decision making.

Hospital documentation

Hospital blood alcohol assays are required to be taken on all major trauma victims admitted into the hospital, as per the Palmerston North Hospital EMT (2000) guidelines. In many cases the blood alcohol assay was omitted. A total of two (3.5%) of the 14 victims reviewed by the panel, who arrived into the emergency department alive, had blood taken for hospital blood alcohol assays. In addition, the two cases transferred out of Palmerston North Hospital for specialist care at other facilities had only very brief nursing progress and medical notes available. The person who was transferred to Burwood Hospital did not have any nursing notes from the time of arrival in the emergency department until transfer to Burwood Hospital later in the day. Neither of these cases transferred out of the hospital had the time of transfer out of Palmerston North Hospital documented in either medical or nursing notes.

The lack of hospital documentation (refer to Table 4.22) for five of the 20 cases evaluated impacted on the analysis of patient care through the trauma system. The expert panel were unable to evaluate the management of one case due to the absence of patient hospital notes or x-rays from the emergency department. The panel did, however, evaluate the preventability of this death from information in the autopsy report.

5.6 An Evaluation of the Methodology used in the Present Study

Following a review of the literature, and the intention to follow as closely as possible the methodology used by Smeeton et al. (1987), a methodology for the present study was determined. The rationale for the employment of the methods used, and those that were unable to be included in the present study will now be discussed.

5.6.1 Survey sample

In order to statistically contextualise the present study in a three year "normative trauma death population", an attempt was made to retrospectively review Coroner's reports for the region. However, it soon became apparent that without correlating these reports with the 'Police 47' and other documentation, it could not be established that these were in fact traumatic deaths and, therefore, comparable to the present study population. Extrapolation to the three year population was abandoned.

5.6.2 Information on bystander assistance

Ambulance officers have commented that in the case of a traumatic incident the public occasionally requests the police after their arrival at the scene, who then contact the ambulance service. This sequence of events wastes time in terms of potential patient survival. For this reason an attempt was made to include data on first bystander response to the incident. Data to be collected included the telephone number dialled (did the caller dial the 111 emergency service number or the local telephone number?), was the call from a cellular phone or a land-line and, which emergency service was requested. Telecom New Zealand Limited declined to provide this information citing the Privacy Act, 1994. In addition, the Telecom service in Palmerston North covers a vast land area and the logistics of tracing the calls was said to be prohibitive by the Telecom supervisor (personal communication, Michelle - Telecom supervisor, May, 18, 1998). Future studies of trauma management systems would benefit from the cooperation of all potential telecommunication providers. In this instance the Privacy Act is considered a convenient excuse from which to avoid participation. Clearly, no information was being sought on the caller.

5.6.3 Methodological variances

Ideally the population of trauma deaths should be evaluated by two or more panels of specialists in order to obtain some statistical agreement on the classification of death. In addition, it is recommended that CNS and non-CNS deaths are evaluated separately (MacKenzie et al., 1992). However, due to the small population of deaths in the present study, it was felt that the use of more than one panel and the separation of case types would not enhance the validity of the study. Furthermore, a standardised method of autopsy reporting and the involvement of a neuropathologist, neither of which were available for the present study, meant that the information required to justify introducing another panel was absent. A neurosurgeon was included in the panel of the present study, however, in order to cover the specialty of CNS-related injuries.

Deaths in the present study were classified using the three categories provided by McDermott et al. (1997) of 'preventable', 'possibly preventable' and 'not preventable' with the addition of the category of 'undecided' (see Appendix Eight). Decisions on the classification of death were initially made by each panel member independently evaluating the cases and then by a group panel discussion. If a consensus at the group meeting was not reached by the panel, then the majority opinion ruled. As stated earlier, there was total panel consensus on 14 of the 20 cases and the majority opinion ruled on the remaining six cases. However, one panel member who had independently rated the deaths was not present at the panel discussion, and this member's initial classification was included. In view of the group discussion of the cases in reaching a consensus, there is a strong possibility that the absent panel member's classification of the deaths may also have changed to concur with that of the rest of the panel. Although the independent review of the cases resulted in vastly different estimates of survival and classifications of death, following the group discussion the panel consensus on each case was virtually unanimous.

5.6.4 Multi-disciplinary panels

One deficiency identified in the Auckland study (Smeeton et al., 1987), and addressed in the present study, was that the evaluation of the Auckland cases was completed by *one intensive care specialist* who, it is assumed, was employed by the Auckland Hospital Board at that time. The review of cases by one internal specialist, introduces a potential for bias and lack of objectivism (Kelly & Epstein, 1997; MacKenzie et al., 1992; Maio et al., 1996).

A multi-disciplinary panel was engaged for the present study with each person carefully chosen for their expertise in a particular field. All members, with the exception of the paramedic, were external to the organisation under review. The potential for influence from the internal panel member was acknowledged. The paramedic was chosen specifically because of the peculiarities of the terrain and the inclusion of such a large number of rural incidents. It was felt that inside knowledge on the logistics of transportation times and accessibility could be discussed more objectively with the inclusion of this particular panel member. Additionally, the paramedic was able to identify difficulties with various cases which were not obvious from the Ambulance Patient Report forms or the 'Police 47s'. For example, incidents which involved multiple vehicles and multiple patients with the need to triage patients accordingly; the availability of emergency service personnel; and, timely accessibility to both trauma victims and equipment were clarified by the paramedic.

As presented in Section 3.9, *Evaluation of Patient Management* in Chapter Three, panel members were provided with set criteria with which to evaluate cases. The method for classification of deaths was provided, as was a series of 'Outcome Questions to be Answered for Each Case' and 'Definition of Problem Categories' for evaluation of the various contributors to the trauma system. The Ambulance Education Council 'Patient Care Procedures and Notes' for evaluation of the appropriateness of pre-hospital care were used as were the St. John Ambulance Service-Central District 'Quality System Procedures' on timeliness and appropriateness of method of transportation. Recognised trauma protocols (EMT, 2000) for Palmerston North Hospital treating personnel and national guidelines on the provision of optimal trauma care (Royal Australasian College of

Surgeons, May 1994) were also used as evaluation tools. The inclusion of these documents facilitated the evaluation of both the general and specific aspects of the management of the trauma patient without leaving the performance of individuals entirely open to personal interpretation.

Results of the evaluation process were presented earlier in Chapter Four in Section 4.9, *Findings from the Expert Panel Review*. The panel was asked to comment on the evaluation process used. The panel members stated that the initial evaluation of the cases was useful for familiarisation with the case and it was 'extremely worthwhile' for each member to independently assess the appropriateness of trauma management and the preventability of death prior to the group panel discussion.

5.6.5 Grading of injuries

A uniform approach to the grading of injuries is recommended by many authors (e.g., Civil, 1997; MacKenzie et al., 1992; McDermott et al., 1994) when undertaking a preventable death study. These authors suggest the use of scoring systems such as the Revised Trauma Score (RTS), the Injury Severity Score (ISS) or the more recently developed TRISS methodology which combines the Trauma Score, the Injury Severity Score (TRISS) and age. Boyd, Tolson and Copes (1987) are advocates of preventable death study evaluation using the TRISS methodology. These authors state that TRISS is useful for comparing national standards, for quality assurance review on a local basis, as well as a means of comparing outcomes for different populations of trauma patients (p 370).

The AIS and ISS methods of grading injuries were used in the present study as these were seen as the most uniform and consistent methods of grading and calculation both in national and international studies. The TRISS methodology was not used for three reasons. First, 36 cases (64%) were found to be in cardiac arrest on arrival of the ambulance service, and the TRISS method of injury scaling requires a baseline pulse and blood pressure for calculating purposes. Second, the small number of cases restricted direct comparisons of a clinical nature with other studies and third, the lack of external validity when comparing the results to other studies with divergent methodologies.

The New Injury Severity Score (NISS) was also incorporated in the present study because of the greater predictability of survival using the NISS scoring system and the perceived likelihood of NISS succeeding the ISS system. In addition, the scoring complexity of the ISS system where every injury must be assigned to one of six body regions before scoring, when these six regions do not correspond to the nine anatomic body regions of the AIS lexicon, makes the NISS system more attractive. It was found that the NISS scoring system provided higher injury severity scores and was, therefore, thought to be more realistic in terms of potential patient survival.

5.6.6 Autopsies

The autopsy report was an essential tool for the expert panel in evaluating the preventability of death for the present study. It is difficult to see how other authors such as Maio et al. (1996), who employed an autopsy rate as low as 20%, were able to accurately evaluate both the cause of the death and then classify the preventability of death. Likewise, clear and accurate clinical notes are essential for analysing the appropriateness of clinical care. Clinical notes alone completed by ambulance service personnel, emergency department staff and all other attending medical and nursing staff have been found to be of limited value in analysing the appropriateness of patient management within the trauma system. The autopsy report, if thorough, provides a definite picture of the injuries that the person died *with*, and depending on the timeliness of the autopsy post-incident, the impact of the injuries which may otherwise have not been obvious at the time of treatment. Conversely, the autopsy report does not always show definitively, what the person died *from*.

In the present study, due to the absence of a standardised procedure for autopsy reporting, a wide variance was noted in the detail provided from forensic autopsies and those cases where a single cause of death was established. It is understood that the primary function of the autopsy is to establish, in the pathologist's opinion, what the cause of death was and not to identify all potential contributing factors to the death. A standardised autopsy procedure which included cervical spine and pelvic x-rays was discussed at the commencement of the study. However, due to the limited availability of a pathologist to perform a standardised autopsy procedure, as well as the limitation of time and funding to include x-rays, this recommendation could not be implemented.

The panel commented on deficiencies in the autopsy reports, presented in Table 4.23. These deficiencies included: failure to mention a dissected aortic aneurysm seen on CT scan; failure to mention a crush leg injury and a fractured pelvis; as well as the inclusion of liver lacerations stated on the autopsy report but not found at laparotomy. Overall the panel felt that although the quality of some of the autopsy reports was limited, there was sufficient information on the 20 cases being evaluated to classify the deaths in terms of death preventability.

5.7 The National Trauma System: A Proposed Policy

Several deficiencies in the trauma system for the greater Manawatu region have been identified. These deficiencies include occasional non-compliance with trauma protocols and guidelines; inadequate clinical decision making; lack of consultation about patient care with tertiary specialists; and, the transfer of patients to inappropriate facilities.

The data collection period for the present study commenced in July 1998 and continued until June 1999. The document, *Roadside to Bedside: A 24-Hour Clinically Integrated Acute Management System for New Zealand*, was published in March 1999. While the process used to identify deficiencies in the national system has not been reported on, it does not appear to include either census or sampling techniques of any statistical significance. While issues of the statistical significance of the present study are acknowledged, notably when attempting to extrapolate the results to a national level, many of the deficiencies noted in the *Roadside to Bedside* document are similar to those recognised by this author.

The *Roadside to Bedside* document (March 1999) written by the Ministry of Health in conjunction with the Health Funding Authority, ACC and the Council of Medical Colleges in New Zealand was produced to articulate key principles and components of an acute personal health system. This acute personal health system outlines the expected level of service to be available to all New Zealanders for the management of trauma, medical and surgical emergencies and complicated births. The authors identified a lack of integrated trauma management in New Zealand and then developed a framework for the delivery of acute services. Deficiencies identified in the report included the following:

- Inadequate clinical decision making about the level of care and the most appropriate form of transportation for trauma patients.

- Fragmented ambulance services (particularly air services).

- Current trauma protocols and guidelines (as at March 1999) not universally adhered too by all agencies and professional groups involved in the management of acute health needs.

The proposed acute management system recommended a 'teams approach' that had an integrated communications network, common standards and protocols, and a system for performance monitoring and continuous improvement. The eight features that were identified as critical in achieving the aims of the acute management system were:

- The establishment of regional networks

- Delivering patients to the nearest hospital capable of providing definitive care, ideally within 'the golden hour'

- Capability for 'rescue'

- Integration of all services

- Appropriate emergency transport systems

- Agreed protocols, guidelines and standards

- Workforce development

- Access to tertiary service specialists via telecommunications and emergency response (p. 5, 1999).

The *Roadside to Bedside* authors recommended better collaboration and communication between traditional healthcare providers and funders and other agencies such as the Police, Fire Service, Civil Defence, Search and Rescue and the Military. An appropriate emergency transport system is recommended with the integration of both land and air systems with a wide range of vehicles including single-crewed ambulances and fixed-wing aircraft.

The section on 'Agreed protocols, guidelines and standards' includes a recommendation for emergency departments to triage within an appropriate time frame which must include a psychiatric liaison for both mental and personal health needs. Funding for emergency transport is to go only to those providers who meet nationally consistent standards within a national accreditation standard.

The authors suggest that the document *Roadside to Bedside* be used as the basis for the implementation of a clinically integrated acute management system based on the consolidation and development of existing services into five regional networks. The authors recognise that there are a significant number of key issues that need to be worked through before the system is fully operational. The schedule for implementation of the proposed system commenced in February 1999 with an anticipated completion date beyond July 2000. Personal communication with associated personnel involved in the project yielded the following information on progress to date:

- The establishment of virtual networks integrating emergency care in five regions based around tertiary hospitals (Emergency Care Co-ordination Teams - ECCTs) has been implemented.

- The five teams will provide an umbrella to establish clear accountabilities and facilitate the collection of quantifiable data to monitor performance and benchmark service delivery.

- Funding for the 'Roadside to Bedside' project for the year 2000/ 2001 has been approved by the Ministry of Health and the Health Funding Authority.

- The Midland Region (Waikato) is currently the only region with an operational ECCT. To date the Midland region has produced an annual report, several papers and facilitated a regional exchange of information.

- The Ministry of Health is currently leading an Inter-agency Working Group on Emergency Transport Services. The group is discussing ways to improve the co-ordination of emergency services between land, air and sea modes of transport; between transport and treatment providers; and, between funders (S. Woollaston, personal communication, October 11, 2000).

5.8 Summary

The demographic profile of the trauma death population for the present study is similar to that found both nationally and internationally. Males were the predominant sex involved in fatal traumas until 55 years of age, females were dominant thereafter. The ratio of road crash deaths and other deaths reflected proportions reported elsewhere. The number of deaths due to suicides in the study region was surprisingly high, and has implications for mental health services, both preventative and therapeutic. Pre-incident factors such as positive blood alcohol levels and inappropriate speed for motor vehicle related deaths was similar to that found in other studies with 24% of the road crash victims testing positive for blood alcohol.

Accessibility to the patient by emergency service personnel plays an important part in the trauma complex. Whether access is delayed because of distance from medical facilities, entrapment in a vehicle or triaging in cases involving multiple trauma victims, this is a significant factor. One which, it has been suggested, serves as a natural triage system in which those persons with non-survivable injuries often die before receiving medical attention.

Compliance of personnel involved in trauma management with current trauma system protocols was discussed and deficiencies noted. However, following the evaluation of the trauma death population by the expert panel, it was felt that these deficiencies did not contribute to any of the deaths evaluated by the panel.

CHAPTER SIX: CONCLUSIONS

6.1 A Précis of the Trauma Management System

The broad aims of the study were first, to establish a database of trauma deaths in the greater Manawatu region and second, to analyse trauma management systems and elements of these systems where appropriate. In addition, it seemed pertinent to make use of the knowledge created by the study to continue public awareness on the abuse of alcohol; the use of safety equipment and safety practices; and, the dangers of excessive speed while using a motor vehicle.

The specific objectives of the study were:

Objective 1. To determine the incidence of death from trauma in the greater Manawatu region during a twelve-month period.

A database of trauma deaths in the Manawatu region for the year from July 1st 1998 to June 30th 1999 was established. There were 56 deaths from traumatic injury that satisfied the criteria for inclusion in the study. Deaths by category of trauma for the population were as follows: 31 (55.3%) road crash victims; 16 (28.5%) deaths due to suicide; five (8.9%) homicidal deaths; and, four deaths due to other causes, namely, a fall, an electrocution, one death due to extensive burns and, one drowning following a head injury. Of all the cases 36 (64%) were found to be 'in cardiac arrest' at the scene of the incident and five cases (8.9%) were 'not in cardiac arrest' but died later at the scene. One case died in transit to hospital and 14 cases (25%) died in hospital. The number of deaths due to suicide was not anticipated and was later reported by Bartlett (1998) as being above average.

The average age of the trauma death population was 36 years: 41 individuals (73%) were under the age of 45 years. There were 34 males (60%) and 22 females (40%). The most prominent age group were the 15 – 24 year-olds, followed by the 35 – 44 year olds. Trauma deaths up to the age of 55 years were predominantly male, thereafter female. There were 40 Caucasians (71%), 14 Maori (25%), one person of full Fijian extraction and one person who was classified as half Fijian. The percentage of Maori trauma victims was also disproportionately high when compared with the population distribution of Maori in the greater Manawatu region.

Blunt trauma accounted for 45 (82%) of the deaths, penetrating wounds accounted for ten deaths (16%), with one death due to burns. The majority of victims sustained more than one injury to a body region. Most deaths were due to multiple injuries: 13 cases; followed by asphyxiation and head injuries, 11 cases each. Other causes of death were injuries to the thoracic aorta (eight cases); cardiac injuries (four); exsanguination (three); fractured cervical spine, and multi-organ failure with septic shock, each with two cases. One individual died of pneumonia following a chest injury and one death was the result of electrocution.

Objective 2. To determine pre-incident factors that may have a bearing on the occurrence of the incident and the nature and severity of the injuries.

Eight (24%) of the 31 road crash victims had positive blood alcohol levels. Three were car drivers; three were motorcyclists - one of whom was riding as a pillion passenger; one person was a rear car-seat passenger; and, one was a pedestrian. Only one of the three car drivers had a blood alcohol level below the legal drink-driving level. High speed was an additional factor in all of these eight alcohol related deaths, recklessness was evident in two deaths. Basic safety practices such as wearing a seat-belt or helmet were not complied with in three of these fatalities. The majority of the motor vehicle related deaths occurred at the scene of the incident and as a result of multiple injuries. The injuries for this group were mainly AIS grade six (maximum) injuries, currently untreatable, or grade five injuries (critical). Only one other person was recorded to have a positive blood alcohol level (blood alcohol assays were not taken on all trauma victims), this was a low level and occurred in one of the suicides.

The geographical location of the incident was found to be a significant factor in the occurrence, the nature and the severity of the injuries. Motor vehicle related deaths predominantly occurred in rural areas and mainly at the scene of the incident. This is likely to be a result of speed, while still within the open road speed limit, on narrow winding roads with unexpected hazards. All of the suicidal deaths by firearms occurred in rural locations, while suicide by hanging occurred predominantly in urban areas.

Objective 3. To determine factors in the trauma management system and other post-incident factors that may have influenced the fatal outcome of the incident.

Post-incident factors identified in this study include the geographical location and ensuing geographical access to the individual which is a vital component in the injury complex. The location of the incident will, in turn, impact on the time taken before emergency medical treatment is available, often encroaching into the 'golden hour'. Other factors that influence the fatal outcome include physical access to the individual by emergency service personnel, the actual injuries incurred, and the provision of timely and appropriate treatment of the injuries if survival is to be a possibility. Although information on triaging at incidents involving multiple victims was not documented, but established following conversations with ambulance personnel, it is the author's impression, that this may also influence the likely survival of the severely injured trauma victim, particularly in rural areas where emergency services are limited.

Factors within the trauma management system which may influence the outcome following a traumatic incident include initiation of bystander first aid, notification and timely location of the victim by the appropriate emergency service and communication between the police, fire service, and the ambulance service. Both the ambulance service and the fire service have written policies for notification of the other service in the case of traumatic incidents involving people. Surprisingly, the police do not.

Additional relevant post-incident factors that may influence the fatal outcome include: the qualification of attending ambulance officers; timely patient referral to an appropriate regional trauma centre; appropriate clinical management of the victim once admitted into the medical facility; and timely consultation of medical personnel with specialists at tertiary hospitals (i.e., neurosurgeons). The utilisation of diagnostic capabilities such as tele-radiology may also be pertinent. As mentioned earlier, the actual injuries incurred in the traumatic incident will have the greatest impact on the duration of survival of the individual.

The trauma management system in the greater Manawatu region was found to function effectively post-incident, evident from the five percent '*possibly* preventable' death rate (one case) for the entire trauma death population over the study period. Although deficiencies were found to have occurred in both the pre-hospital and hospital phases of patient management, these deficiencies were not considered to have contributed to any of the deaths. Pre-incident factors in trauma deaths, however, have a significant impact on the occurrence of the event, and although some of these factors have been documented, there are many that remain unknown. Pre-incident factors, unlike post-incident factors are unable to be controlled by any aspect of the trauma management system.

Objective 4. *To describe relationships between the mortality of the victim, and other factors such as age and prior morbidity.*

Ischaemic Heart Disease, Chronic Obstructive Respiratory Disease and psychiatric history were all significant factors in those deaths where co-morbidity occurred. Advanced age, seventy years and over, was also considered to be significant in the deaths of three cases reviewed by the expert panel.

Objective 5. *To review current trauma systems and trauma management in the greater Manawatu region in order to identify any deficiencies and make recommendations to improve trauma management systems.*

A number of deficiencies were noted throughout the trauma management system in both the pre-hospital and in-hospital phases of care. Pre-hospital deficiencies included: failure to call a paramedic to the scene of an incident; failure and delayed dispatch of a helicopter; poor patient assessment; late IV access; insufficient IV fluid resuscitation; failure to intubate and one case of inappropriate extubation. In-hospital deficiencies included: failure to administer a blood transfusion (the patient was known to be of the Jehovah's Witness faith); diagnostic procedures being performed on haemodynamically unstable patients; failure to consult with tertiary specialists; failure to adhere to ICU treatment protocols; and, failure within the Mental Health Service to accurately assess suicidal persons. Inadequate and inaccurate documentation hindered the evaluation of systems in the context of the present study and reduced the efficacy of the analysis of the trauma management system. Although these deficiencies were observed, they were not found to have influenced any of the deaths. Recommendations for improvement follow in Section 6.3.

Objective 6. *To identify the preventable trauma deaths within the study population.*

The expert panel fully evaluated 20 deaths and the progress of these persons through the trauma management system. The panel found that 18 of the deaths were 'not preventable', one death was unable to be classified due to insufficient information, and one death was classified as 'possibly preventable'.

6.2 An Overview

Pre-incident factors that may have contributed to the deaths in the present study population, such as positive blood alcohol levels, use of safety equipment and safety practices, were collated where known. However, in a number of incidents this information was not available. Other mitigating contextual factors within the trauma death population remain either unknown and/or unrecorded such as erratic driving behaviour, cocktails of drugs and alcohol, and in the case of suicides, extenuating financial circumstances. While contextual factors such as these appear to contribute significantly to the trauma death population, their accurate analysis in terms of clinical pre-incident factors is problematic.

Some of the clinical deficiencies identified as such in the context of the trauma management system should be interpreted as independent clinician management. Despite the existence of trauma protocols there will be instances when treatment according to protocol is not perceived as being in the patient's best interest by the attending clinician.

The value of hindsight, with the availability of autopsy reports and the ability to evaluate patient care without the pressure of an emergency situation, should not be underestimated. Although the expert panel found deficiencies within the trauma management system, the panel determined that these deficiencies did not have any direct effect on the fatal outcome of any of the cases reviewed. This is evident by the expert panel's findings of only one possibly preventable death (5%) within the annual trauma death population in the region.

Some 72% of the trauma deaths occurred within one hour of the incident, a further 12% died within four hours and the balance (16%) died within seventeen days. These results are not dissimilar to those found by Trunkey (1983) who developed the theory of the trimodal distribution of trauma deaths. Trunkey identified that about half of all individuals who incur a major traumatic insult will die immediately, a further 30% will die within a few hours. The remaining 20% are expected to die within days or weeks post insult. The main causes of death in the present study were multiple injuries following blunt trauma. The location of the death with multiple injury is a direct reflection on the severity of the injuries sustained; the accessibility of the victim by emergency service personnel; the geographical location of the incident; and, the effectiveness of the trauma management system that is in place.

Data obtained from the present study showed that despite individuals incurring injuries with a high ISS/NISS score, there were a surprising number of cases where the victims did not die immediately, but died within the 1- 4 hour period, identified by Trunkey as 'early deaths'. For example, of the eight deaths that occurred following injury to the thoracic aorta (AIS grade 5), six were immediate, one occurred in-transit and one occurred in hospital. Similarly, of the 11 cases of death due to asphyxiation, nine occurred at the scene, and two occurred in hospital. These latter two cases had vital signs present (were not in cardiac arrest) when found and received CPR at the scene. In comparison, the 16% of late deaths were not unanticipated. These deaths occurred in cases where a head injury was sustained and the skull fractured, allowing cerebral decompression to occur. Two other late deaths occurred when the co-morbidity was a significant factor in the injury complex, and one death was the result of septic shock following extensive burns.

If the trauma system in the greater Manawatu region had been flawless during the twelve month study one life may have been saved – approximating 5% of the trauma death population. However, as noted above some of the trauma victims survived longer than anticipated, but their injuries were such that death was inevitable for at least 72% of them. Of the 12% that died within 1 - 4 hours post insult, all but one of these individuals (case 16 - the possibly preventable death) had sustained injuries that were fatal, as determined by the expert panel. Within the five percent window of opportunity for improvement, factors such as relevant co-morbidity, accessibility to the patient both physically and geographically, must be optimal before this one life can be saved. This finding supports that of Maio et al. (1996) who claimed that in rural Michigan, under similarly ideal circumstances, trauma mortality could reasonably be expected to fall by only 10% or less. In the greater Manawatu region, the opportunity to improve the trauma management system at the time of the study, was only five percent.

6.3 Recommendations

The first section includes recommendations to further improve trauma death studies. These recommendations include the enhancement of data, data collection, and data analysis. Suggestions for practitioners are presented in the second section, these include issues concerning emergency services, communications, the coronial system and trauma management systems. Directions for future research are then identified.

6.3.1 Methodological issues for future Trauma Death Studies

During the conduct of the research several issues were encountered that had they been anticipated or incorporated in previous studies would have assisted the processes of research design, data collection and/or analysis. Data on the participation of bystanders, the police, fire service personnel and ambulance service personnel at the scene of the incident ought to be obtained. In the first instance this should include the initiation of contact with emergency services and second, the administration of basic first aid. This information will assist in the analysis of both public participation, excluded from this and most other studies of trauma death, and the knowledge of basic life saving procedures.

The results of this information could be used to better target public education. For example, the inability to maintain a patent airway *could* be overcome by mandatory first aid qualifications in conjunction with drivers' licence tests, and five-yearly updates on first aid with the renewal of driver's licenses.

Methodology for future trauma death studies should include information on the individual's employment status; current occupation; financial position (particularly in relation to suicides, e.g., farmers); and, socio-economic status.

Information collected from motor vehicle incidents should utilise both the 'Police 47' and the 'traffic crash' report. A traffic crash report is completed by the police at the scene of the incident and collates information on the environment, for example, road conditions, visibility and weather. The traffic crash report is more likely to include information on the use of safety equipment and speed than the 'Police 47.' This pre-incident information may contribute to the contextual factors identified in the previous section.

The NISS method of injury scoring and expected survival should be used. The NISS system of injury scoring is more simplistic and appears to be a better predictor of patient survival than the ISS. Further, the trauma death population should be stratified by age and injury severity in order to increase reliability of the sample if generalisations are to be made to a broader population.

Trauma death studies should be standardised to use a four-way classification of 'preventable', 'possibly preventable' and 'not preventable' deaths, with the addition of 'undecided'. These classifications are simple and unambiguous. Evaluation of the trauma death population using a multi-disciplinary panel provides a sound basis for discussion and clarifies aspects of individual clinical management by the specialists involved.

An independent evaluation of the trauma death population should be conducted prior to the panel evaluation. This technique provides each panel member with an opportunity to familiarise themselves with the data and make an independent assessment of each case within their capacity as a specialist. It also provides the panel member with an opportunity to discuss the clinical management of the patient from their own perspective. Each panel member should independently submit their final evaluation of patient management and classification of the death following *both* the independent and group review. Withholding the autopsy report would ensure that the evaluation of clinical management was not obscured by the knowledge of an inevitable death. The process could subsequently be repeated with the benefit of the autopsy report, and comparisons then made.

6.3.2 Improvements to the Trauma Management System

It is recommended that the police adopt a policy requiring notification of the ambulance service and the fire service when they are first notified of a traumatic incident prior to their departure for the scene. The 'golden hour' may be further eroded when the police attend an incident and only notify the ambulance service upon their arrival. This delay could be critical in rural incidents.

Documentation of information on both the Ambulance Patient Report and the 'Police 47' should be reviewed by the respective services. The Ambulance Patient Report does not assist in the analysis of patient management and clinical decision making when information on incidents involving multiple victims and the subsequent need to triage occurs but is not stated. Likewise, the documentation of information on the availability of resources such as other emergency personnel who were also in attendance should be encouraged. The 'Police 47' form should be reviewed. A clear distinction should be made between pre-incident and post-incident information.

The appointment of a Chief Coroner is recommended to establish and maintain a system to oversee Coroners within regions. This perspective has recently been endorsed by the Law Commission (NZPA, 2000). The appointment of a Chief Coroner would provide a nation-wide mechanism through which coronial practices could be both standardised and monitored. For example, the Coroner's Act, 1988 requires mandatory autopsies for all victims of trauma death, however, in practice this does not occur.

An alarming number of traumatic deaths in the study population were due to suicides. And the study *only* encompassed those suicides of a traumatic nature. It was stated by numerous authors following information provided by regional Coroners (e.g., Bartlett, 1998; NZPA, 2000) that this rate of suicides was unprecedented. Information on both regional and national trends like these are otherwise unavailable to researchers. The existence of a centralised information register on trauma deaths may have facilitated an earlier review of these suicidal deaths. The establishment of such a register, as well as a review of pre-disposing factors to suicidal deaths, could well be warranted.

As part of a quality assurance programme, all general hospitals should be recommended to undertake three-yearly audits of trauma populations (efficacy studies – which include live and dead trauma victims) in order to evaluate trauma management systems and patient care. It is also recommended that coronial pathologists introduce a standardised system of autopsy reporting which includes pre-mortem clinical information and a full set of cervical spine and pelvic x-rays for victims of trauma death. In addition, a basic drug screen should be included for common drugs.

6.3.3 Directions for future research

Information on timeliness from the occurrence of the incident until the arrival of the emergency service is unknown. It is recommended that an audit of timings within the various stages of a traumatic incident is undertaken, with respect to the final outcome. Examples include: the time from the incident until the victim is found; how long before the emergency service is notified; what method of notification was used (i.e., land line, cellphone); what was the response time of the telecommunications agency; and when was the ambulance dispatched and the victim located.

Various initiatives have been introduced to reduce the road toll, such as drink driving campaigns and speed cameras. The existence of help-lines for those with suicidal tendencies has also been publicised. In the trauma death population for the year mid -1998 – mid -1999, data from the present study showed that the population of trauma deaths in the greater Manawatu region could only be reduced by some 5%. An opportunity exists for trauma management systems research to explain if this margin for improvement in the annual population of trauma deaths can be reduced further, and if this can be achieved through directing funding towards pre-incident factors such as injury prevention, better policing of roads and 'drink drivers'. Such research will need to encompass mitigating contextual factors in addition to the pre- and post-incident factors described in this report.

It is thought that the percentage of preventable deaths within the Manawatu region is as low as five percent because an effective trauma system was in existence in the region at the time of the study. Medical personnel with an interest in trauma management and the subsequent flow on effect has resulted in the establishment of guidelines for the attending 'trauma team', regular updates for both medical and nursing staff on the management of emergency situations, and the initiation of a trauma registry. The opportunity exists for further research to be conducted in an area with a similar geography and population distribution, also serviced by one second-level hospital, that does not currently have a regional trauma management system in place. The results could then be compared. This information may then be used to better direct funding towards hospital trauma management systems on a national basis.

This study evaluated the population of deaths by trauma and the subsequent management of those victims within a region. It allowed clinicians and personnel involved in the trauma system to assess where the deficiencies in the system lay, and in hindsight, to then evaluate the trauma management process. An efficacy study (encompassing both live and dead trauma victims) which included those deaths which occurred at the scene, in transit and in hospital, as did the present study, would provide a balance of information on all trauma cases. Those trauma victims who survived the ordeal may have been better managed and their quality of life improved if various processes had been initiated. Regular efficacy studies would, therefore, provide a more accurate perspective and evaluation of the trauma management system within a region.

The Land Transport Safety Authority (LTSA) recently attributed rural road deaths in rural areas to rural dwellers, as opposed to urban dwellers. The location of the incident may or may not, reflect the victim's home location. This issue warrants further investigation.

The liberalisation of marijuana is currently under debate. While information on alcohol in motor vehicle related deaths was included in the study, information on other drugs, both licit and illicit, was not collected. However, data was made available on the two cases where it was established that a cocktail of alcohol and drugs had been taken and may have impaired the victim's judgement. This information may be used for the consideration of liberalisation of marijuana; education of the general public; agencies involved in health and safety; and, personnel involved in trauma management.

Over the past few years aspects of the three emergency services throughout New Zealand have become centralised. The opportunity exists to establish if the centralisation of emergency service control rooms has reduced effective intra-service communications and resulted in an increase in the number of errors in dispatch and direction of vehicles in traumatic incidents.

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GLOSSARY

Abbreviated Injury Scale (AIS): A list of several hundred injuries, each with an assigned severity score that can range from 1 (minor injuries) to 6 (injuries that are nearly always fatal).

ACC: Accident Rehabilitation and Compensation Insurance Corporation.

Advanced Care Officer (ACO): Also known as Paramedic, ambulance officer qualification.

Advanced Life Support (ALS): Includes basic Life Support plus the use of drugs and equipment.

Abbreviated Injury Scale (AIS).

Anti-shock garment: see MAST.

Apnoeia/apnoeic: The cessation or absence of spontaneous respiration.

Advanced Trauma Life Support (ATLS/ATS): Specialist care of trauma victims involving equipment and drugs.

American College of Surgeons Committee on Trauma (ASCOT): A major trauma outcome study with a pool of data on injured trauma patients developed to test survival probability norms based on severity indices.

Autopsy: Dissection of a dead body, in order to ascertain by actual inspection the cause or seat of disease (also known as post mortem examination).

Basic Life Support (BLS): The first line management of airway, breathing and circulation.

Cardiac arrest: The absence of cardiac activity.

Cerebral haematoma: (Cerebral) relating to the cerebrum / head, (haematoma) a swelling containing blood.

Contusion: A bruise or injury which does not break the skin, caused by a blow, characterised by swelling discolouration and pain.

Co-morbidity: (Co) together, (morbid) diseased or relating to an abnormal or disordered condition, (co-morbidity) – associated or pre-existing illness.

Computed Tomography (CT scan): A series of x-rays taken on the same axial plane. The computer then creates a composite picture of various tissue densities. A diagnostic technique.

Chronic Obstructive Respiratory Disease (CORD): Airways disease due to conditions such as chronic bronchitis, emphysema and asthma which results in chronic respiratory insufficiency.

Cardio-Pulmonary Resuscitation (CPR): Basic life support which includes rescue breathing and chest compressions.

Central Nervous System (CNS) involving the central nervous system – the brain and spinal cord.

Craniotomy: A surgical opening into the skull performed to relieve intracranial pressure or to control bleeding.

Creutzfeld-Jacob Disease (CJD): A strain of bovine encephalitis (Mad Cow Disease).

Dead On Arrival (DOA): Absence of life.

Degloving injury: An injury where all flesh is removed exposing the bone.

Diagnostic Peritoneal Lavage (DPL): Lavage –the process of washing out an organ. Used as a diagnostic tool to ascertain the presence of blood in the peritoneal cavity signifying internal bleeding.

Early Management of Severe Trauma (EMST): A series of guidelines for the management of trauma patients by clinicians.

Early Management of Trauma (EMT): Palmerston North Hospital guidelines on trauma management.

Environmental Science and Research Institute (ESR): A government department where drug and alcohol testing is done.

Glasgow Coma Scale (GCS): A scale used to assess the patient's response to the environment through eye opening, verbalisation and movement. These responses are then scored from 3 – 15, the latter which is awarded to an individual who is fully awake and orientated.

Golden Hour: A term used to describe the period of time during which the adverse physiological consequences of shock following injury can still be reversed, coined by R. Adams Cowley, the "father of trauma surgery" at the Maryland Institute for Emergency Medicine (MIEMISS) in the early 1970s.

General Practitioner (GP): A doctor in general practice.

Haemodynamics: The study of physical aspects of blood circulation including cardiac function and peripheral vascular physiology.

Hospital levels I, II, III (see ICU levels I-III).

Haemothorax: An accumulation of blood and fluid in the pleural cavity between the parietal and visceral pleura, usually the result of trauma.

Haemomediastinum: The presence of blood in the mediastinal space (see mediastinum).

Hyperventilation: An increased frequency of breathing, an increase in tidal volume, or a combination of both, causing excessive intake of oxygen and the blowing off of carbon dioxide. A ventilation rate that is greater than that metabolically necessary for the exchange of respiratory gases.

Hypoventilation: A decrease in respiratory function, occurring when the volume of air that enters the alveoli and takes part in gas exchange is not adequate for the metabolic needs of the body.

Hypovolaemia: An abnormally low circulating blood volume.

Hypoxia: A diminished amount of oxygen in the tissues.

Intermediate Care Officer (ICO): An Ambulance Officer qualification.

Intensive Care Unit (ICU): A hospital unit in which patients requiring close monitoring and intensive care are housed.

ICU, Level I: An intensive care unit capable of providing immediate resuscitative management for the critically ill, short term cardio-respiratory support which has a major role in monitoring and prevention of complications in 'at risk' medical and surgical patients.

ICU, Level II: An intensive care unit capable of providing a high standard of general intensive care which supports the hospital's other roles in general medicine, surgery, trauma management, neuro-surgery, vascular surgery etc. Also provides ventilatory support, invasive haemodynamic monitoring and dialysis support.

ICU, Level III: An intensive care unit which provides the widest level of care, monitoring and therapy required by its referral role as well as that required by the delineated role of the hospital. The unit should provide all aspects of intensive care medicine and should be a tertiary referral unit.

Ischaemic Heart Disease (IHD): Heart disease with compromised blood flow.

Intensivist: An intensive care specialist.

'In cardiac arrest': Apnoeic (not breathing), pulseless and unconscious.

Intravenous Catheter/Cannulae (IV): A catheter inserted into a vein to supply medication or nutrients directly into the blood stream, or for diagnostic purposes such as studying blood pressure.

Intubation: Passage of a tube into a body aperture, specifically the insertion of a breathing tube through the mouth or nose or into the trachea to ensure a patent airway for the delivery of anaesthetic gases and oxygen.

Injury Severity Score (ISS): An index of anatomic injury severity used for describing patients with multiple injuries and evaluating emergency care. The ISS is the sum of the squares of the highest score on the Abbreviated Injury Scale (AIS) in the three most severely injured body regions.

Injury Prevention Research Unit (IPRU).

Land Transport Safety Authority (LTSA).

Laparotomy: A surgical incision into the peritoneal cavity.

Maximum Abbreviated Injury Score (MAIS): The highest single AIS code awarded to a patient with multiple injuries.

Mediastinum: A portion of the thoracic cavity in the middle of the thorax between the pleural sacs containing the two lungs and extending from the sternum to the vertebral column.

Military Anti-Shock Trousers (MAST): A suit used to control blood pressure in shocked patients.

Motorbike Accident (MBA).

Motor Vehicle Accident (MVA).

Myocardial Ischaemia (MI): A heart attack.

Neurosurgeon: A surgeon specialising in medicine concerned with the brain, spinal cord or peripheral nerves.

Non-CNS: not involving the central nervous system.

'Not in cardiac arrest': Patient breathing, pulse present and may or may not be conscious, vital signs still present.

New Zealand Ambulance Board (NZAB).

Orthopaedic surgeon: A surgeon specialising in medicine concerned with the treatment of the musculoskeletal system by manipulative or operative methods.

Paediatrician: A physician concerned with the development and care of children, their diseases and prevention.

Pathologist: One who studies the causes and nature of disease.

Paramedic: Ambulance officer qualification also known as ACO – Advanced Care Officer.

Patient Information Management Systems (PIMS). A computer programme containing patient information.

Pneumothorax: A collection of air and gas in the pleural space causing the lung to collapse.

Post mortem: After death.

Pulseless: The absence of a pulse.

Regional Control Centre (RCC): Ambulance control centre from where the ambulance and helicopter is dispatched.

Regional Health Authority (RHA).

Revised Trauma Score (RTS): An injury grading system which uses three physiologic parameters to quantify injury severity – Glasgow Coma Scale, systolic blood pressure and respiratory rate. The coded value for each variable is then multiplied by an assigned weight. The sum of the three products is the RTS.

Scoop and run approach: A medical term for the management of injured patients which requires that the minimum amount of medical intervention is provided at the scene of the incident and the patient is transported to hospital as soon as possible (the opposite to the 'stay and stabilise' approach).

Serum sodium level: The level of sodium within the serum/blood. Normal range is 136 - 144 millimols per litre.

Stay and stabilise approach: A medical term, the opposite to the 'scoop and run' approach, where an injured patient is given relevant medical intervention at the scene of the incident in order to stabilise the patient's condition before transportation.

T-Boned: Hit in a perpendicular fashion (a term used with motor vehicle accidents when a vehicle is hit side-on).

Total Body Surface Area (TBSA): The surface area of a body, used with victims of burns.

Thoracotomy: A surgical incision into the thoracic cavity.

Trauma: Physical injury or thermal burns.

Trauma team: A team of hospital personnel who are called to attend victims of major trauma on their arrival to hospital. The trauma team consists of the Emergency Department House Officer; the ICU Registrar; the General Surgical Registrar; the Anaesthetist on call; the Emergency Department Nursing Staff; the Nursing Co-ordinator (after hours); the Radiographer on call and the Transfusion Medicine Laboratory Technician.

Trauma Score (TS): An injury grading system using four physiologic parameters –systolic blood pressure, capillary refill, respiratory rate, and respiratory expansion combined with the Glasgow Coma Scale.

Triage/triaging: A/the process by which a group of patients is sorted according to their need for care.

TRISS: A combination of the Trauma Score, the Injury Severity Score and the patient's age.

APPENDIX ONE

Calculating the Injury Severity Score (ISS)

Calculating the Injury Severity Score (ISS)

A. General rules

The ISS is the sum of the squares of the highest AIS code in each of the three most severely injured ISS body regions. The six body regions of injuries used in the ISS are:

1. Head or neck
2. Face
3. Chest
4. Abdominal or pelvic contents
5. Extremities or pelvic girdle
6. External

Head or neck injuries include injury to the brain or cervical spine, skull or cervical spine fractures.

Facial injuries include those involving mouth, ears, eyes, nose and facial bones.

Chest injuries and injuries to abdominal or pelvic contents include all lesions to internal organs in the respective cavities. Chest injuries also include those to the diaphragm, rib cage, and thoracic spine. Lumbar spine lesions are included in the abdominal or pelvic area.

Injuries to the extremities or to the pelvic or shoulder girdle include sprains, fractures, dislocations, and amputations, except for the spinal column, skull and rib cage.

External injuries include lacerations, contusions, abrasions, and burns, independent of their location on the body surface.

Note again that these ISS body regions do not necessarily coincide with the sections used in the AIS. For example, the AIS Spine section is divided into three ISS body regions: cervical in ISS Head or Neck, thoracic in ISS Chest, and lumbar in ISS Abdominal or Pelvic Contents.

The following example should help in understanding the ISS calculation.

ISS BODY REGION	INJURY	AIS CODE	HIGHEST AIS	AIS²
HEAD/NECK:	Cerebral contusion Internal carotid artery, complete transection	140602.3 320212.4	4	16
FACE:	Ear laceration	210600.1	1	
CHEST:	Rib fractures left side, ribs 3-4	450420.2	2	
ABDOMEN:	Retroperitoneal hematoma	543800.3	3	9
EXTREMITIES:	Fractured femur	851800.3	3	9
EXTERNAL:	Overall abrasions	910200.1	1	
				ISS = 34

ISS scores range from 1 to 75. A score of 75 results in one of two ways, either with three AIS 5 injuries, or with at least one AIS 6 injury. Any injury coded AIS 6 is automatically assigned an ISS of 75. However, the coder is instructed to code all the injuries in that patient even though the ISS will not be altered by additional injuries. It is not possible to calculate an ISS on a patient who has any code 9 injury; hence, the need to press for detailed injury information.

B. Coding Injuries to the Skin

In AIS 85, minor and moderate (AIS 1-2) injuries to the skin and penetrating injuries were coded under the External section and assigned to the External body region for calculating the ISS. These injuries have now been dispersed across body regions to help in locating them and are marked with asterisks. (See External Injuries on page 6 for rationale.) This change in practice should not affect the overall severity assessment.

The following rules should be applied in calculating the ISS scores involving external injuries:

- If the asterisked injury is the only injury in a body region, locate it under the body region in which it occurs but assign it to ISS body region, External.
- If the asterisked injury accompanies an injury to a deeper structure, code the asterisked injury under the body region in which it occurs. The injury to the deeper structure in that body region will take precedence over the external injury for ISS.
- If minor (AIS 1) external injuries occur in multiple body regions but are the only injuries, code as a single injury under External (e.g., multiple contusions would be coded as Contusion, code 910400.1, under External body region).

APPENDIX TWO

Report for Coroner "Police 47"

REPORT FOR CORONER

POLICE 47
05/00

		Code		Result		Sector Code
Deceased:	Mr/Mrs/Miss/Ms	I	S	[redacted]	5	[redacted]

	Address in Full:		Hm Phone:
Marital Status: Race:			Bus Phone:
Maiden Name:	Occupation:		D.O.B.
Place of Death:	Date of Death:	Time:	
Next of Kin: Mr/Mrs/Miss/Ms	Address in Full:		Hm Phone:
			Bus Phone:
Relationship: Sex:	Date:	Time Informed:	
Person who identified body: Mr/Mrs/Miss/Ms	Address in Full:		Hm Phone:
			Bus Phone:
Relationship: Sex:	Date:	Time:	
Deceased last seen alive by: Mr/Mrs/Miss/Ms	Address in Full:		Hm Phone:
			Bus Phone:
Sex:	Date:	Time:	
Person who found deceased: Mr/Mrs/Miss/Ms	Address in Full:		Hm Phone:
			Bus Phone:
Sex:	Date:	Time:	
Doctor who confirmed death: Mr/Mrs/Miss/Ms	Address in Full:		Hm Phone:
			Bus Phone:
	Date:	Time:	
Person who informed Police: Mr/Mrs/Miss/Ms	Address in Full:		Hm Phone:
			Bus Phone:
	Date:	Time:	

Undertaker engaged by Police:	Body Removed to:

Coroner/JP: (Name)	Notified By:	QID CHA409	Time 13:00	Date 23/11/2000

Deceased's Doctor:	Medical Centre:	Hm Phone:
		Bus Phone:

Supervisor Attended Scene: Yes / No	Supervisor Name:	QID:

SUMMARY:	Property of Deceased Taken? Yes/No

Reporting Member:	Station	QID		
			Card Event No:	File:

APPENDIX THREE

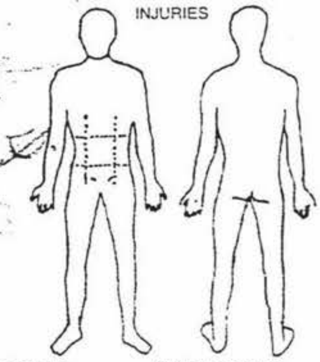
Ambulance Patient Report

AMBULANCE PATIENT REPORT

NATIONAL STATUS CODE
0 1 2 3 4

DAY	MONTH	YEAR	RUN NO.	UNIT
			454 22	3 4 2

INJURIES



PATIENT DETAILS

TITLE: MR MRS MISS MS (CIRCLE) DATE OF BIRTH: AGE

FAMILY NAME FIRST NAMES

ADDRESS TELEPHONE No.

LOCATION

DESTINATION ☐ AH ☐ ACH ☐ GLH/NWH ☐ NSH ☐ MMH ☐ PVTE A&E OTHER:

PRIMARY ☑ SECONDARY ☐ HELICOPTER ☐

Despatched 1306 Located 1326

Departed Destination

F Fracture
L Laceration
A Abrasion
S Swelling
H Haemorrhage
T Tenderness
C Contusion
D Dislocation
B B
P P

X Position of
→ Point of imp
Damaged A
Seatbelt Not/Wor
Estimated Impact Sc
High Medium L

FRONT

CHIEF COMPLAINT DOA.

History of depression. Found by wife sitting on couch. Rifle between his knees.
O/A: Pt as above. O/E Pt cyanosed.
° Pulse ° Resp. Not seen for 2+ hours.
Body not touched - Police in attendance.

ALLERGIES

TREATMENTS	TIME	DOSE	ROUTE

MOTOR RESPONSE SCENE		ED	VERBAL RESPONSE SCENE		ED	EYE OPENING SCENE		ED
6	Obeys Command	6	5	Oriented	5	4	Spontaneous	4
5	Purposeful Movement	5	4	Confused	4	3	To Voice	3
4	Withdraw	4	3	Inappropriate	3	2	To Pain	2
3	Flexion	3	2	Incoherent	2	1 ✓	None	1
2	Extension	2	1 ✓	None	1			
1 ✓	None	1						

	NORMAL	ABNORMAL
A		✓
B		✓
C		✓
LOC		✓

TIME	PULSE	RESPS	BP	GCS	PAIN SCORE 0-10	SpO_2
INITIAL				3		
ED						

Skill Use
01 Oral airway
02 Splint
03 Traction
04 C-collar
05 KED
06 Entonox
07 Salbutamol
08 Defib
09 IV attempt
10 IV success
11 MAST in pla
12 MAST inflat
13 GTN
14 NP Airway
15 Cricoth
16 ET attempt
17 ET success
18 Frusemide
19 Atropine
20 Lignocaine
21 Adrenaline
22 Sodable
23 Dext 50%
24 Glucagon
25 Midazolam
26 MS
27 Metoclop
28 Naloxone
29 Stesolid
30 Chest Deco

POSTURE		OXYGEN	
Recovery	1	Mask.......L/mn	1
Supine	2	Nasal Cath.......L/mn	2
Head Elevated	3	28% Venti Mask	3
Legs Elevated	4	Reservoir Mask	4
Sitting	5	Bag/Mask	5

CARDIAC ARREST (YES / NO)
BYSTANDER CPR PRIOR TO ARRIVAL
EFFECTIVE?
WITNESSED?
PRIVATE RESIDENCE

INTIAL RHYTHM	
VF	1
ASYSTOLE	2
EMD	3
IVR	4
SINUS RHYTHM	5
OTHER	6

TIME OF FIRST SHOCK (if VF)

TOTAL SHOCKS

COMMUNICATION WITH MEDICAL FACILITY ☐ DR

431951

1ST OFFICER'S NAME	NUMBER	2ND OFFICER'S NAME	NUMBER	3RD OFFICER'S NAME	NUMBER
	433			Student Nurse	

SKILLS SKILLS SKILLS

APPENDIX FOUR

Map of the Greater Manawatu Region and Location of Regional Ambulance Stations

Paramedic Base

Palmerston North

Wanganui

Levin

Fulltime Ambulance Stations

Feilding

Otaki

Foxton

Pahiatua

Dannevirke

Raetihi

Waiouru

Taihape

Marton (Monday – Friday 8am.-6pm. only)

Stations staffed by volunteers

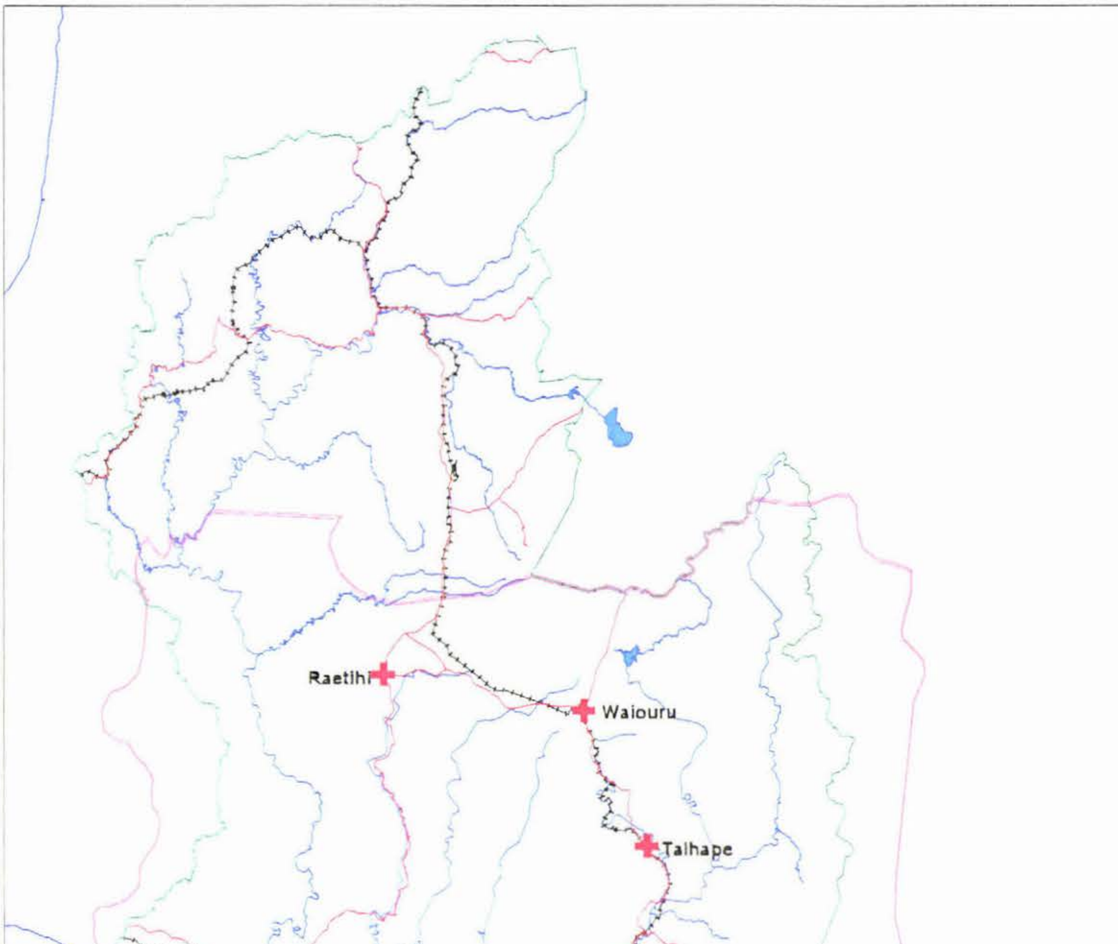
Marton (weekends and nights)

Hunterville

Woodville

Eketahuna

Pongaroa



Map 1 - horizons.mw Region

APPENDIX FIVE

Facsimile form from Palmerston North Hospital Mortuary

Trauma Study

Attention:- Caroline Lockhart
telephone (06) 323 3540
fax (06) 323 3542

Date received:

Aut. number:

Aut. date:

Cor:	Hubbard	Chisnall	Smith	Comber	Evans
	Brown				
Path:	Darby	Lockett	Temple-Camp	Pang	
Blood Alc:	Taken	Not taken			

APPENDIX SIX

Policy Document on Triage

AUSTRALASIAN COLLEGE FOR EMERGENCY MEDICINE

POLICY DOCUMENT

TRIAGE

Patients will be triaged into one of five categories on the National Triage Scale according to the traigeur's response to the question: "THIS PATIENT SHOULD WAIT FOR MEDICAL CARE NO LONGER THAN ...."

NATIONAL TRIAGE SCALE		TREATMENT ACUITY
Resuscitation	1	Immediate
Emergency	2	Minutes (within 10 minutes)
Urgent	3	Half Hour
Semi Urgent	4	One Hour
Non Urgent	5	Two Hours

According to local requirements a numeric or colour code may be used to represent the triage categories. For standardisation, the following codes will be used:-

NATIONAL TRIAGE SCALE	NUMERIC CODE (where used)	COLOUR CODE (where used)
Resuscitation	1	Red
Emergency	2	Orange
Urgent	3	Green
Semi Urgent	4	Blue
Non Urgent	5	White

APPENDIX SEVEN

Trauma Death Study Data Collection Form

Trauma Death Study Form

Checklist (state - not applicable / completed)
Ambulance Station Computer Printout (ASCP)
Ambulance Patient Report (APR)
Police 47
Autopsy report
Blood alcohol
Hospital records
Form completed

Identifiers:

Study No:

Incident date:
Incident time:

Data collection dates:

Coroner: Pathologist:
Autopsy no: Autopsy date:

Police records no:

Paramedic base: Palm. Nth Levin Wanganui
or Ambulance base: (state)

Patient hospital no:

Personal demographics:

Surname:
Christian names:
Date of Birth:
Gender: Male Female
Ethnicity:
Town/City of residence:

Event details:

Location: (longitude/latitude)
Description of location: (state)

Event details:

Place:	urban	rural		
Activity:	work	sport	leisure	domestic
	other (state)			
Intent:	unintentional	self inflicted	inflicted by other/s	
Injury type:	road crash	off road crash	fall	blow
	other blunt	penetrating	burn	other(state)

Product involved or cause: (state)

Behavior: (as a cause of the event) appropriate inappropriate

Causal factors: (if any)

Emergency code: (patient status)

Vehicle: (if appropriate)

Type of vehicle:	car	truck	bicycle	tractor
	motorcycle		other (state)	

X position of patient
--- point of impact
damaged area

vehicle front

Driver:	yes	no
Safety equipment:	seatbelt	yes/no
	helmet	yes/no
	car seat	yes/no
	other (state)	

Estimated impact speed: high medium low

Causal vehicle: yes no

Number of vehicles involved:

Death:

Date:
Time:
Location: at scene in transit in hospital

Reason for death: bleeding brain airway respiratory

multi-organ failure other (state)

Pathophysiological cause:

Text:

Process of care: (if death not instant)

Amb job no: Amb report no: Area code:

Emergency call received:

Code:

	A	R	L	T	D	F
	Assigned	Responded	Located	Transported	Destination	Finished
Amb. No.						

Victim transported by: ambulance helicopter other (state)
Text:

Pre Hospital:

First Ambulance officer qualification:	Elementary	Proficiency	ICO

1. Name:
2. Name:
3. Name:

Paramedic involved in care	yes	no
IV cannula inserted	yes	no
Endotracheal intubation	yes	no
Chest decompression	yes	no
CPR performed	yes	no

Initial GCS (Glasgow Coma Scale):
Other treatment: (state)

In-Hospital:

First Hospital: (name)
Admission GCS:

Second Hospital: (name)

Second hospital admission	date:	time:

Transfer reason: (state)

Admitted to ICU (first hospital)	date:	time:
Admitted to ICU (second hospital)	date:	time:
Location of death:	ICU	ward

Operations: (if performed)

No	Date/time	Operation	Specialty	ICD9CM

Injuries:

No	Injury Description	Region	AIS Code	ICD9CM	

AIS (Abbreviated Injury Score) code:

ICD-9 (International Classification of Diseases) code:

Relevant co-morbidity:

Other:

Post Mortem Ethanol:
Hospital ethanol:

Problems in care: (if found on review)

Phase of care: Injury before EMS notified

response of EMS at scene

with transportation first hospital second hospital

Problem:

Comments:

APPENDIX EIGHT

Panel Review Forms

- 'Classification Of Death' (McDermott, F.T., Cordner, S. M., Tremayne, A. B., and The Consultative Committee on Road Traffic Fatalities in Victoria (1997). Management deficiencies and death preventability in 120 Victorian road fatalities (1993-1994). *Australian, New Zealand Journal of Surgery, 67,* 611-618.

- 'Outcome Questions Answered for Each Case' (Maio et al. 1996). A study of preventable trauma mortality in Rural Michigan. *The Journal of Trauma, Injury, Infection, and Critical Care, 41* (1), 83-90.

- 'Categorisation of Problems' (McDermott, F.T., Cordner, S. M., Tremayne, A. B., and The Consultative Committee on Road Traffic Fatalities in Victoria (1997). Management deficiencies and death preventability in 120 Victorian road fatalities (1993-1994). *Australian, New Zealand Journal of Surgery, 67,* 611-618.

CLASSIFICATION OF DEATH

A ***preventable death*** is defined as one where, in retrospect, with full knowledge of the clinical history and all injuries sustained, that the chances of survival would have exceeded 75% with optimal treatment.

A ***potentially preventable death*** is defined as one where, in retrospect, with full knowledge of the clinical history and all injuries sustained, that the chances of survival would have attained 25-75% had the patient received optimal treatment. That is, with the expectation that the patient had been triaged effectively to a hospital with the appropriate facilities in the minimum amount of time and appropriate management had been promptly provided.

A ***non-preventable death*** is defined as one where, in retrospect, with full knowledge of the clinical history and all injuries sustained, that the chances of survival with optimal management were less than 25%.

A classification of ***'Undecided'*** is one where either there is insufficient information available for you to be able classify the death, or you feel that it is not within your area of expertise.

Reference: McDermott, F. T., Cordner, S. M., Tremayne, A. B., and The Consultative Committee on Road Traffic Fatalities in Victoria (1997). Management deficiencies and death preventability in 120 Victorian road fatalities (1993-1994). Australian, New Zealand Journal of Surgery, 67, 611-618.

OUTCOME QUESTIONS ANSWERED FOR EACH CASE

QUESTIONS	POSSIBLE RESPONSES	COMMENTS
1. How would you characterise the patient's outcome, given the patient's injuries and circumstances	• As expected • Worse than expected • Much worse than expected	
2. From what you know about the patient's injuries, what do you believe would have been this patient's chance of survival assuming excellent care throughout his/her management	• 0% • <25% • <50% • >50% • >75%	
3. From what you know about the patient's injuries and care, what was the principal cause of death?	• CNS injury • Airway • Haemorrhage/shock • Other • Indeterminate	
4. Do you consider the patient's death to have been preventable, potentially preventable, not preventable or undecided.	• Preventable (chances of survival > 75%) • Potentially preventable (chances of survival 25-75%) • Not preventable (chances of survival < 25%) • Undecided (insufficient information or not within your area of expertise)	
5. If potentially preventable, please indicate the percentage of preventability.	• 25 - 49% • 50 - 75%	

6. Was inappropriate/inadequate care a significant contributing factor to the patient's death?	• Yes • No	
7. Would improvements in the trauma system (rather than in the performance of individuals) have improved this patient's chances of survival?	• Yes • No	
8. (from question 7) If yes, which aspects of the trauma system? (tick all that apply)	A. Patient identification (found time) B. EMS system notification C. Timeliness/level of prehospital response/care D. Initial delivery to appropriate level hospital (if available) E. Initial assessment/stabilisation in emergency department F. Timeliness of surgical evaluation/care G. Timeliness of transfer for definitive care H. Accessibility of trauma centre care I. Treatment protocols at hospital providing definitive care J. Other system improvement	

Reference: Maio, R. F., Burney, R. E., Gregor, M. A., & Baranski, M. G. (1996). A study of preventable trauma mortality in Rural Michigan. The Journal of Trauma, Injury, Infection, and Critical Care, 41 (1), 83-90. (with modifications).

CATEGORISATION OF PROBLEMS

A. **System inadequacy:** failure or insufficiency of the trauma system to deliver appropriate and timely care (i.e. to provide appropriate medical/ambulance staff or facilities).

Comments:

B. **Error in treatment or management strategy:** a therapeutic or diagnostic decision made contrary to data available at the time (management plan for the patient not in accordance with recommended optimal standards of practice, e.g. EMST guidelines).

Comments:

C. **Error in technique:** technical error during the performance of a diagnostic or therapeutic procedure.

Comments:

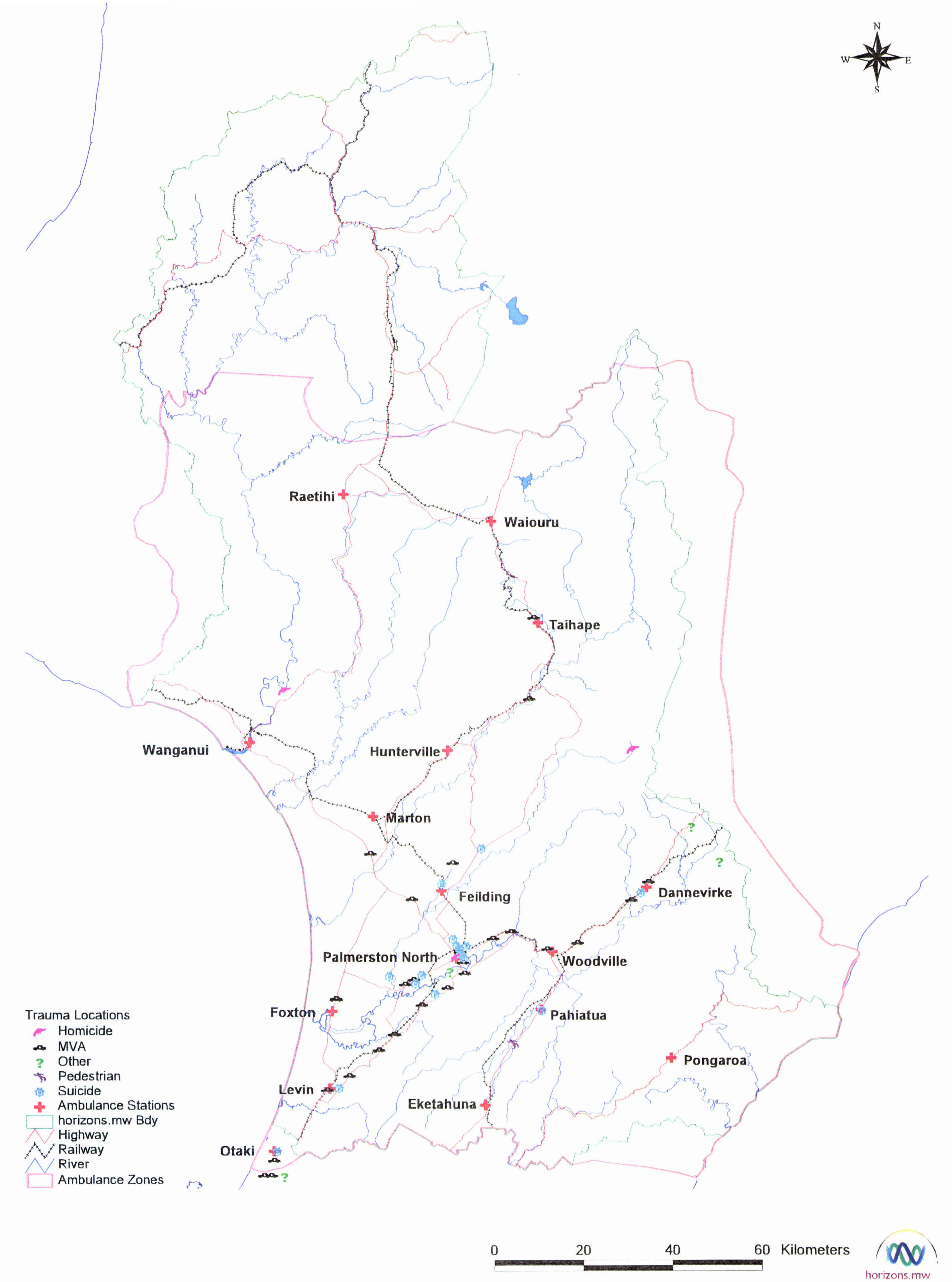
D. **Error in diagnosis:** injury not diagnosed because of misinterpretation, inadequacy or lack of clinical examination or diagnostic procedure(s).

Comments:

E. **Delay in diagnosis:** diagnosis not made in a timely fashion when considered in the context of the patient's overall condition.

Comments:

Reference: McDermott, F. T., Cordner, S. M., Tremayne, A. B., and the Consultative Committee on Road Traffic Fatalities in Victoria (1997). Management deficiencies and death preventability in 120 Victorian road fatalities (1993-1994). Australia, New Zealand Journal of Surgery, 67, 611-618.



Trauma Locations

Arcview Project Path \\PNT_081\D:\PROJ\RESUSE\BURT\TRAUMA MAPS\TRAUMA LOCATIONS

APPENDIX NINE

Map of Fatalities

APPENDIX TEN

Abbreviated Injury Scale (AIS) System

The Purposes and Philosophies of the AIS

The AIS was developed to provide researchers with a simple numerical method for ranking and comparing injuries by severity, and to standardize the terminology used to describe injuries. Since 1971, the need for greater sophistication of these goals has driven several revisions of the AIS. Throughout these revisions, the scope of injuries has been broadened, not only to include an expanded list of injury descriptors, but also to include injuries other than those that occur in a vehicular environment. Increasing the sophistication of the description of the injuries has allowed the AIS to be utilized in more data collection efforts than ever before. Whereas early versions of the AIS were principally suited for large scale vehicular data, the most current revisions are now also useful to medical researchers involved in clinical circumstances. Because of its responsiveness to these needs, the AIS has become accepted worldwide and has facilitated comparative injury research.

Despite the changes that have occurred in the revisions, the AIS attempts to remain true to the basic principles that were involved in its genesis. These principles have dictated the utility, as well as the limitations, for which the AIS has been useful. First, the AIS is based on anatomical injury and in this way differs from other systems that depend on physiological parameters. The consequence of this principle is that there is only a single AIS score for each injury for any one person, whereas in scales that depend on physiological measures, many scores are possible for a single patient depending on how the person's physiology changes over time. Second, the AIS scores injuries and not the consequences of the injuries. This principle has been employed so that the AIS can be used as a measure of the severity of the injury itself and not as a measure of impairments or disabilities that result from the injury. As the AIS has progressed, immediate consequences of several injuries have been included as part of certain injury descriptors in order to specify injury severity more precisely. Examples involve the brain (loss of consciousness), blood vessels or solid organs (amount of hemorrhage), and chest (pneumothorax). Third, the AIS is not simply a ranking of expected mortality from injury. Were this the case, there would be no way to distinguish the majority of minor and moderate injuries since they pose little or no threat to life. Although empirical data show that the AIS correlates well with the probability of death at the serious and life-threatening levels (AIS $\geq$ 3), other factors are also considered in AIS severity. These include potential for mortality, as well as the diagnostic certainty, rapidity, duration, complexity and expected effectiveness of resolution with or without existing therapy. These factors are difficult to quantity but must be considered since severity is continually redefined by the progress of medicine. It is anticipated that the AIS will continue to be refined according to these basic principles of its structure.

Assessment of Multiple Injuries

The Abbreviated Injury Scale (AIS) is a consensus derived, anatomically based system that classifies individual injuries by body region on a 6-point ordinal severity scale ranging from AIS 1 (minor) to AIS 6 (currently untreatable). The AIS does not assess the combined effects of multiply-injured patients.

The Maximum AIS (MAIS), which is the highest single AIS code in a patient with multiple injuries, has been used by investigators to describe overall severity. Its usefulness remains important in motor vehicle injury research concerned with vehicle design changes. In trauma research, however, the MAIS was found lacking due to its nonlinear relationship with the probability of death. Also, death rates vary significantly within each AIS value for the most severe injury depending upon the AIS value for the second most severe injury.

Baker's Injury Severity Score (ISS) published in 1974 gives a much better fit between overall severity and probability of survival.[8,9] The ISS is the sum of the squares of the highest AIS score in three different body regions. [See page 10 for instructions on how to calculate the ISS.]

ICD-AIS Compatibility

In 1986 MacKenzie et al published their ICD-AIS conversion table, its developmental work and potential uses.[10] The conversion table translates ICD-9CM coded discharge diagnoses into AIS body regions and severity codes. With AIS 85 it was possible, applying a list of assumptions, to match satisfactorily a number of AIS injury diagnoses and ICD rubrics. The extent to which this will be possible with AIS 90 is yet to be determined.

AIS 90 IMPROVEMENTS

The improvements in AIS 90 result from almost two decades of clinical and research applications of the system. These improvements are discussed briefly.

Coding Guidelines

Injury data collection can be hampered because of problems with the scales, the information available to the coder, or the coders themselves. The standardization of injury terminology and the expansion of the AIS from its original 75 injury descriptions in 1971 to over 2,000 to accommodate both blunt and penetrating trauma has diminished the inadequacies of earlier scales. Further, the AAAM offers training seminars to those responsible for extraction and interpretation of injury information.

The problems with inadequate injury information are more difficult to solve than those of scales and coders. For example, an autopsy report of "multiple blunt trauma resulting in death" does not provide any specific information on the injuries and is virtually useless for injury coding purposes. Though not as grossly inadequate, even hospital charts can be deficient in detail or can give contradictory information from one piece of the hospital record to another.

AIS 90 includes specific rules within the dictionary itself to solve some coding dilemmas such as when there is a choice of descriptions or body regions to which an injury can be assigned, or when clinical diagnoses can be used. Synonyms and parenthetical descriptions are used extensively to allow the coder to appropriately match the injury description in the hospital chart with one in the AIS dictionary. These coding rules together with coder training should improve intra- and interrater reliability.

Penetrating Injuries

AIS 85 introduced some descriptions that allowed coding of penetrating injuries, such as gunshot and stab wounds. In addition, clinical terminology that routinely is used to describe penetrating injuries to the vascular system, thoracic and abdominal organs was included. Coding experience since 1985 using these descriptors suggested improvements, especially in the terminology. In AIS 90, penetrating injury descriptions are compatible, to the extent possible, across all body regions. The AIS codes for the vascular injuries reflect empirical clinical research findings of the last several years, notably from the Major Trauma Outcome Study (MTOS).[11]

Pediatric Injuries

Age can be an important variable in relation to injury severity. It is well documented that an older patient will have a higher probability of unfavorable outcome than a healthy younger person given the same injury severity. Very young children may similarly be worse off.

Several years ago, Baker convened a group of pediatric trauma surgeons to review all of the injury descriptions in AIS 85 and their AIS severity codes to determine which did not apply to a pediatric population. Of the more than 2,000 diagnoses, these trauma specialists agreed that all but about 15 adequately reflected relative severity of injuries in young children. These exceptions related to the size of brain hematomas, blood loss in severe lacerations, or internal bleeding, by volume, due to abdominal or thoracic injuries. The Committee on Injury Scaling concurred in these proposed changes and in a few cases felt that the changes applied to all age groups. These revisions are incorporated into AIS 90.

Expanded Injury List

The AIS does not measure impairment or disability. A scale that would complement the AIS and provide a link between injury severity and societal costs is fundamental. Several scales have been suggested or are underway.[12-14]

A framework for constructing an impairment scale has recently been proposed by States,[15] and work on its development has been undertaken by the AAAM Committee on Injury Scaling. The criteria for such an impairment scale are being deliberated. In anticipation of this new scale, the list of injuries in the AIS has been expanded to accommodate the addition of an impairment severity code. Even when the AIS code is the same for a number of different injuries to an organ, the relative impairment of these injuries may be quite different; thus the need for more definitive injury diagnoses.

Numerical Injury Identifier

AIS 85 introduced a unique 6-digit code for each injury diagnosis to assist in computerization of data. The addition of injury descriptions in AIS 90, especially in the brain and extremities, has required a more flexible numerical system than that used in 1985.

In AIS 90, each injury description is assigned a unique 6-digit numerical code in addition to the AIS severity score. As summarized in the diagram below, the first digit identifies the body region; the second digit identifies the type of anatomic structure; the third and fourth digits identify the specific anatomic structure or, in the case of injuries to the external region, the specific nature of the injury; the fifth and sixth digits identify the level of injury within a specific body region and anatomic structure. The digit to the right of the decimal point is the AIS score:

The following conventions are used in assigning the numerics to specific injury descriptions:

1. Body Region

1	Head
2	Face
3	Neck
4	Thorax
5	Abdomen
6	Spine
7	Upper Extremity
8	Lower Extremity
9	Unspecified

2. Type of Anatomic Structure

1	Whole Area
2	Vessels
3	Nerves
4	Organs (incl. muscles/lig.)
5	Skeletal (incl. joints)
6	Head - LOC

3. Specific Anatomic Structure or Nature

Whole Area

02	Skin - Abrasion
04	- Contusion
06	- Laceration
08	- Avulsion
10	Amputation
20	Burn
30	Crush
40	Degloving
50	Injury - NFS
60	Penetrating
90	Trauma, other than mechanical

Head - LOC

02	Length of LOC
04, 06, 08	Level of Consciousness
10	Concussion

Spine

02	Cervical
04	Thoracic
06	Lumbar

Vessels, Nerves, Organs, Bones, Joints are assigned consecutive two digit numbers beginning with 02.

4. Level

Specific injuries are assigned consecutive two-digit numbers beginning with 02.

To the extent possible, within the organizational framework of the AIS, 00 is assigned to an injury NFS as to severity or where only one injury is given in the dictionary for that anatomic structure. 99 is assigned to an injury NFS as to lesion or severity.

APPENDIX ELEVEN

Data Set of Trauma Deaths

Table A11.1. Injuries by case for all trauma deaths in the greater Manawatu region 1 July, 1998 to 30 June, 1999.

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
1	Homicide – stabbing		• Major aortic laceration with root involvement – 420212.5 • Pericardial injury with tamponade – 441604.3 • Laceration to diaphragm – 440604.3			Injury to the thoracic aorta
2	Motor vehicle incident	• Fractured base of skull – 150202.3 • Petechial haemorrhages - 140642.4	• Major laceration to aorta with haemorrhage not confined to mediastinum – 420218.6			Injury to the thoracic aorta
3	Suicide - (gunshot wound to		• Unilateral lung laceration with blood loss > 20% by volume – 441436.4		• Penetrating injury with tissue loss – 716004.2	Cardiac injuries

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
	chest)		• Lacerated pericardium – 441602.2 • Multiple lacerations to myocardium - 441016.6			
4	Suicide - (hanging)	• Severe cerebral swelling - 140666.5				Asphyxiation
5	Fall	• Scalp avulsion (major) – 110804.2 • Complex fracture to base of skull with loss of brain tissue - 150206.4 • Massive destruction of cranium and brain – 113000.6	• Fractured ribs > 3 on both sides with haemothorax or pneumothorax – 450242.5 • Unilateral lung laceration – 441430.3 • Minor laceration to thoracic aorta – 420208.4	• Major liver laceration (disruption of < 50% of hepatic parenchyma) - 541826.4	• Dislocated wrist - 751430.2	Multiple injuries
6	Suicide - (hanging)	• Severe cerebral swelling – 140666.5				Asphyxiation
7	Suicide - (hanging) head not examined					Autopsy report states "death due to hanging"
8	Motor vehicle incident	• Fractured base of skull with CSF leak – 150204.3 • Moderate cerebral swelling – 140664.4	• Major laceration to thoracic aorta not confined to mediastinum - 420218.6			Injuries to the thoracic aorta

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
		• Petechial haemorrhages to cerebrum – 140642.4	• More than 3 fractured ribs on one side, < than 3 ribs on other side - 450230.3			
9	Excluded from study: Traumatic injury secondary to initial insult					
10	Suicide - (hanging) head not examined					Autopsy report states "death due to hanging"
11	Homicide – (accidental) gunshot wound to chest		• Lung contusion – 441402.3 • Major aortic laceration with haemorrhage not confined to mediastinum – 420218.6 • Complex rupture of trachea and main stem bronchus – 442610.5 • Unilateral lung laceration with blood loss > 20% by volume – 441436.4			Injury to the thoracic aorta
12	Motor vehicle incident		• Major laceration to thoracic aorta haemorrhage not confined to mediastinum -	• Retroperitoneal haemorrhage or haematoma - 543800.3	• Fractured shaft of femur - 851814.3	Injuries to the thoracic aorta

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
			420218.6			
13	.Suicide - (gunshot wound to head)	• Complex fractures to vault of skull with loss of brain tissue - 150406.4 • Penetrating injury to cerebrum – 140690.5				Head injuries
14	Motor vehicle incident	• Small cerebral haematoma – 140632.4 • Severe cerebral oedema – 140674.5 • Brain stem contusion – 140204.5 • Intraventricular haemorrhage – 140678.4			• Fractured femur - 851800.3	Cerebral contusions
15	Excluded from study: Traumatic injury secondary to initial insult					
16	Motor vehicle incident	• Petechial haemorrhages to cerebrum –140642.4		Kidney contusion – 541610.2		"Inhalation of vomitus following cerebral contusion"
17	Suicide – (gunshot	• Complex fracture to base of skull with				Head injuries

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
	wound to head)	loss of brain tissue – 150206.4 • Penetrating injury to cerebrum - 140690.5 • Brain stem contusion - 140204.5				
18	Motor vehicle incident		• More than 3 fractured ribs on one side, < 3 ribs on other side – 450230.3 • Unilateral lung laceration - 441430.3 • Pericardial laceration - 441602.2 • Multiple lacerations to myocardium - 441016.6	• Minor liver lacerations – 541822.2 • Minor lacerations to spleen - 544222.2		Cardiac injuries
19	Motor vehicle incident				• C5 - C6 Incomplete spinal cord syndrome (with preservation of some sensation or motor function) – 640210.4 • Fractured tibia –	"Death resulted from IHD and CORD complicated by acute alveolar damage and cardiac failure"

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
					853404.2	
20	Car versus train (no autopsy)	• Some head injuries visible				
21	Car versus train	• Fractures to vault of skull – 150402.2 • Multiple small cerebral contusions - 140622.3 • Brain stem contusion - 140204.5	• Lung contusion 441402.3			Head injuries
22	Motor vehicle incident		• Fractured sternum – 450804.2 • Fractured ribs with flail chest - 450260.4			"A result of pneumonia following a chest injury"
23	Motor vehicle incident	• Comminuted fractures to the skull - 150404.3 • Subarchnoid haemorrhage - 140684.3 • Small cerebral contusion - 140622.3 • Cerebral lacerations -140688.4	• Severe myocardial contusions -441006.4 • More than 3 fractured ribs on one side, < 3 ribs on other side with haemo/pnuemo thorax - 450232.4	• Major kidney contusion - 541614.3 • Massive laceration to spleen - 544228.5		Multiple injuries

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
24	Suicide - (hanging) head not examined					Autopsy report states "death due to hanging"
25	Head injury/ Drowning	• Depressed fracture to vault of skull – 150404.3				Head injuries
26	Motor vehicle incident	• Comminuted fractures to vault of skull - 150404.3 • Multiple cerebral contusions - 140624.4 • Subcortical haemorrhage to cerebrum - 140644.4	• Flail chest - 450260.4 • Fractured ribs with haemo/pneumo thorax - 450214.3 • Unilateral lung laceration - 441430.3			Multiple injuries
27	Suicide - (hanging) head not examined					Autopsy report states " death due to hanging"
28	Motor vehicle incident	• Fractured base of skull - 150200.3 • Small cerebral contusions – 140606.3	• Perforated myocardium – 441012.5 • More than 3 fractured ribs on each side with haemo/pneumo thorax - 450240.4 • Unilateral lung	• Minor liver laceration - 541822.2 • Minor laceration to spleen - 544222.2 • Minor laceration	• Fractured thoracic spine without cord contusion or laceration - 650416.2 • Fractured femur -	Multiple injuries

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
			laceration – 441430.3 • Complex laceration distal to main stem bronchus - 440210.4 • Major laceration to pulmonary artery – 421008.4 • Pericardial laceration – 441602.2	to kidney - 541622.2	851800.3	
29	Pedestrian (intentional) NB: coded con-servatively	• Massive destruction of cranium (skull) and brain – 113000.6	• More than 3 fractured ribs on both sides with haemo/pneumo-thorax 450242.5 • Major laceration to pulmonary vein – 421206.4 • Injury to pericardium – 441699.2	• Major laceration to abdominal aorta (complete transection) - 520208.5 • Massive rupture of colon - 540826.4 • Massive rupture of stomach - 544426.4 • Massive rupture of pancreas - 542832.5 • Massive avulsion of liver - 541830.6	• Complete fracture and dislocation of lumbar spine – 640650.5 • Fractured humerus - 752600.2 • Fractured radius - 752800.2 • Massive destruction of bone and muscles of knee and above – 813004.3 • Amputation above knee – 811004.4	Multiple injuries

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
					• Substantial deformation and displacement of pelvis – 852606.4	
30	Motor vehicle incident		• More than 3 fractured ribs on both sides with haemo/pneumo thorax – 450232.4 • Major laceration to thoracic aorta with haemorrhage not confined to mediastinum – 420218.6			Injuries to the thoracic aorta
31	Suicide - (gunshot wound to head) no autopsy	• Police report states half of head removed				
32	Suicide - (hanging) visual autopsy – head not examined					Autopsy report states "death due to hanging"
33	Suicide - (hanging)					Autopsy report states "death due

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
	head not examined					to hanging”
34	Electrocution		• Fractured rib – 450210.1		• Minor burns - 912000.1	Electrocution
35	Motor vehicle incident	• Cerebral contusions - 140602.3 • Intraventricular haemorrhage - 140678.4	• Unilateral lung laceration – 441430.3			Multiple injuries
36	Motor vehicle incident	• Comminuted fractured vault of skull - 150404.3 • Multiple cerebral contusions - 140620.3 • Intraventricular haemorrhage - 140678.4	• More than 3 fractured ribs on one side, > than 3 ribs on other side with haemo/pneumo thorax – 450232.4 • Fractured sternum – 450804.2			Multiple injuries
37	Motor vehicle incident	• Fractured base of skull - 150200.3 • Intraventricular haemorrhage - 140678.4 • Small cerebral contusions - 140622.3	• More than 3 fractured ribs on one side < than 3 ribs on other side with haemo/pneumo thorax – 450232.4	•	• Fractured lumbar spine with cord contusion - 640604.3 • Fractured femur - 851800.3	Head injuries
38	Excluded from study: Traumatic injury secondary to initial insult					

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
39	Motor vehicle incident	• Brain stem contusion - 140204.5 • Large, multiple cerebral contusions - 140616.4	• Unilateral lung laceration – 441430.3	• Major liver contusion - 541814.3	• Fractured femur - 851800.3	Multiple injuries
40	Excluded from study: Traumatic injury to secondary to initial insult					
41	Motor vehicle incident		• Lung contusion – 441402.3	• Minor liver lacerations - 541822.2 • Minor lacerations to spleen - 544222.2	• Open pelvic fracture - 852604.3 • Major laceration to femoral artery - 820208.4 • Fractured femur - 851800.3	Exsanguination
42	Motorbike incident	• Petechial haemorrhages (cerebrum) - 140642.4	• Fractured sternum – 450804.2 • Lacerated pericardium -441602.2 • Unilateral lung laceration - 441430.3 • Complex ventricular rupture to myocardium - 441014.6	• Moderate liver laceration (more than 3cms deep with major duct involvement) – 541824.3	• Comminuted fracture to radius - 752804.3 • Comminuted fracture to tibia - 853404.3	Cardiac injuries
43	Motor vehicle incident	• Fractured base of skull - 150200.3 • Intraventricular	• More than 3 fractured ribs on both sides with haemo/pneumo thorax	• Moderate liver laceration – 541824.3	• Fractured cervical spine without cord	Fractured cervical spine

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
		haemorrhage - 140678.4 • Petechial haemorrhages to cerebrum - 140642.4	- 450242.5		contusion or laceration - 650216.2 • Fractured femur - 851800.3 • Open fracture to tibia - 853404.3	
44	Motor vehicle incident	• Intraventricular haemorrhage - 140678.4	• More than 3 fractured ribs on one side, < than 3 ribs on other with haemo/pneumo thorax - 450232.4 • Flail chest - 450260.4 • Minor laceration to brachiocephalic artery - 420406.3	• Laceration to the mesentary – 542020.2 • Moderate liver laceration – 541824.3		Multiple injuries
45	Motor vehicle incident		• Ruptured diaphragm - 440604.3	• Major laceration to the abdominal aorta - 520208.5		Injuries to the abdominal aorta
46	Suicide - (hanging) head not examined					Autopsy report states "death due to hanging"
47	Suicide - (hanging) head not examined					Autopsy report states "death due to hanging"

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
48	Motorbike incident	• Lacerated pericardium - 441602.2 • Major laceration to superior vena cava - 421806.4				Cardiac injuries
49	Motorbike incident	• Comminuted fracture to vault of skull – 150404.3 • Cerebral lacerations – 140688.4 • Petechial haemorrhages (cerebrum) – 140642.4		• Minor laceration to liver – 541822.2	• Comminuted fractured ulna - 753204.3 • Fractured femur NFS - 851800.3 • Fractured femur NFS - 851800.3	Head injuries
50	Motorbike incident		• Complex laceration or ventricular rupture to myocardium - 441014.6 • Major laceration to thoracic aorta with haemorrhage not confined to mediastinum – 420218.6		• Open fracture of pelvis - 852604.3 • Fractured shaft of femur - 851814.3 • Fractured shaft of femur - 851814.3	Injuries to the thoracic aorta
51	Motorbike incident		• Open 'sucking' chest wound – 415000.4 • >3 fractured ribs on	• Moderate liver laceration (> 3 cm deep with	• Massive destruction of larynx - 340212.5	Multiple injuries

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
			both sides with pneumothorax – 450240.4 • Perforation to trachea and main stem bronchus – 442608.4 • Ruptured diaphragm – 440604.3 • Perforation distal to main stem bronchus – 440208.3 • Bilateral lung lacerations – 441450.4 • Complex lacerations to myocardium – 441014.6 • Major laceration to thoracic aorta with haemorrhage confined to mediastinum – 420210.5	major duct involvement) - 541824.3 • Moderate laceration to spleen (no disruption to parenchyma) - 544224.3	• Comminuted fractured radius – 752804.3 • Fractured femur – 851800.3 • Open fracture to pelvis – 852604.3 • Fractured thoracic spine without cord contusion or laceration - 650416.2	
52	Motor vehicle incident	• Brain stem laceration - 140212.6 • Complex fractured vault of skull - 150406.4 • Cerebral laceration -	• Unilateral lung laceration – 441430.3 • Major laceration to thoracic aorta - 420210.5 • Ruptured diaphragm - 440604.3	• Moderate liver laceration - 541824.3 • Moderate laceration to spleen - 544224.3	• Open fractured tibia - 853404.3 • Fractured femur - 851800.3	Multiple injuries

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
		140688.4				
53	Excluded from study: Traumatic injury secondary to initial insult					
54	Pedestrian (un-intentional)	• Petechial haemorrhages to cerebrum - 140642.4 • Intraventricular haemorrhage to cerebrum - 140678.4 • Cerebral contusion - 140602.3	• Unilateral lung laceration with haemo/pneumo-thorax - 441430.3	• Major liver laceration (disruption to < 50% of hepatic parenchyma) – 541826.4		Multiple injuries
55	Suicide – slashed wrist and neck				• Skin laceration with blood loss > 20% by volume - 310606.3 • Major laceration to external jugular vein - 320606.3	Exsanguination
56	Homicide – cyclist hit and run	• Subarachnoid haemorrhage (cerebellum) - 140466.3	• Ruptured diaphragm - 440604.3 • Fractured ribs > 3 ribs on one side and < 3 on other side with haemothorax or pneumothorax - 450232.4	• Major laceration to inferior vena cava - 521206.4	• Complete laceration to cervical spine with dislocation - 640274.6 • Comminuted fracture to tibia - 853422.3	Multiple injuries

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
			• Major fracture to trachea and main stem bronchus with laryngeal-tracheal separation – 442616.5 • Perforated trachea – 442608.4			
57	Homicide – stabbing			• Oesophageal laceration NFS - 440804.3	• Major laceration of larynx – 340212.5	Asphyxiation
58	Homicide – stabbing	• Cerebral oedema (mild) - 140670.3			• Carotid artery laceration (major) – 320408.3 • Major laceration to internal jugular vein - 320806.3	Exsanguination
59	Motor vehicle incident	• Fractured base of skull - 150200.3 • Petechial haemorrhages to cerebrum - 140642.4 • Intraventricular haemorrhage - 140678.4	• More than 3 fractured ribs on both sides – 450240.4	• Massive laceration to mesentary - 541826.4	• Fractured cervical spine with dislocation - 640276.6 • Fractured femur - 851800.3	Fractured cervical spine
60	Car versus train	• Complex fracture to base of skull - 150206.4	• Bilateral lung laceration with or without haemo/	• Major liver laceration (disruption to <		Multiple injuries

Case no.	Mechanism of death	Injuries to head	Injuries to thorax	Injuries to abdomen	Injuries to other body regions	Cause of death
		• Laceration to cerebellum - 140474.4	pneumothorax - 441450.4 • Major laceration to thoracic aorta with haemorrhage not confined to mediastinum – 420218.6	50% of hepatic parenchyma) – 541826.4 • Major laceration to kidney (extending through renal cortex, medulla and collecting system) - 541626.4		
61	Burns				• 2nd and 3rd degree burns to 90% total body surface - 912032.6	Multi-organ failure and septic shock

APPENDIX TWELVE

Contract for the Purchase and Provision of Services

CONTRACT FOR THE PURCHASE

AND

PROVISION OF SERVICES

Between

Central Regional Health Authority

and

The Order of St John Auckland Regional Trust Board

March 1994 Title Contracts: Central RHA
Midcentral Health + Goodhealth Wagari

Authors. J. Bain Deputy chairman regional trust board.
+ P. Bradley
N. W. Peacock.

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(5) maintain all ambulances operated by the service in good order and repair;

(6) when deciding the type of ambulance to be despatched, consider despatch of an air ambulance when the long term prospects for recovery of the patient is likely to be seriously and adversely affected in any delay in the receipt of appropriate medical treatment or the patient would be subjected to prolonged and unacceptable levels of pain or distress if transported by any other means;

Response Times

(7) make all reasonable endeavours to maintain the following service levels during each calendar month for the term of this Contract but subject to review by 30 September 1994.

TYPE OF CALL	URBAN SERVICE AREA	RURAL SERVICE AREA
	(Palmerston North Wanganui and Levin)	(Areas outside Palmerston North, Wanganui and Levin)
Category C Priority 1 as defined in Schedule C)	Arrive at Request Point within 10 minutes from time of call for 80% of calls.	Arrive at Request Point within 16 minutes from time of call for 80% of calls.
	Arrive at Request Point within 20 minutes from time of call for 95% of calls.	Arrive at Request Point within 30 minutes from time of call for 95% of calls.
Category C Priority 2 (as defined in Schedule C).	Arrive at Request Point within 30 minutes from time for 80% of calls.	Arrive at Request Point within 45 minutes from time of call for 80% of calls.

In the event of circumstances beyond your control which make it impracticable for you to comply with the requirements of this Clause, you will immediately notify us of that inability to so comply and of the steps being taken to remedy the situation.